US005975090A

United States Patent [19]

Taylor et al.

[11] Patent Number: 5,975,090

[45] Date of Patent: Nov. 2, 1999

[54] ION EMITTING GROOMING BRUSH

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[73] Assignee: Sharper Image Corporation, San Francisco, Calif.

[21] Appl. No.: 09/163,024

[22] Filed: Sep. 29, 1998

[51] Int. Cl.[6] A45D 19/16

[52] U.S. Cl. 132/116; 132/154; 132/272; 607/79

[58] Field of Search 132/112, 116, 132/188, 152, 154, 271, 272; 607/79

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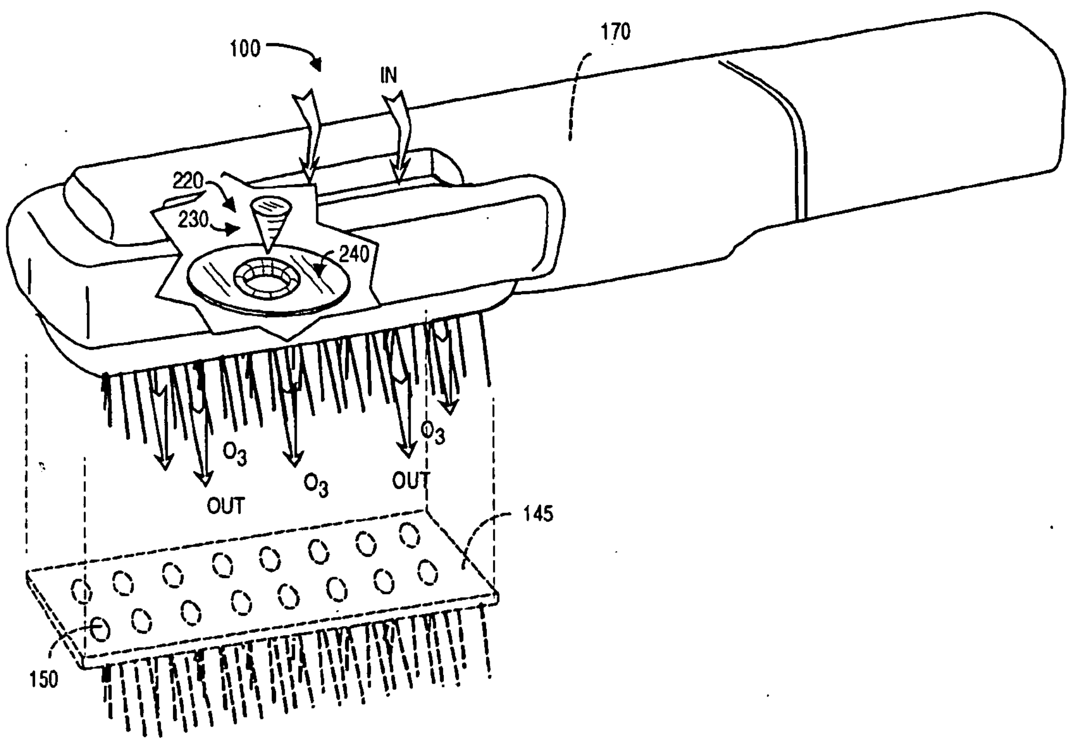
Primary Examiner—Todd E. Manahan
Attorney, Agent, or Firm—Flehr Hohbach Test Albritton & Herbert LLP

[57] ABSTRACT

A hair brush includes a self-contained ion generator that subjects the hair and scalp being brushed to an outflow of ionized air containing safe amounts of ozone. The ion generator includes a high voltage pulse generator whose output pulses are coupled between first and second electrode arrays. Preferably the first array comprises at least one metal pin spaced coaxially-apart from a metal ring-like structure. Alternatively, the first array may comprise one or more wire electrodes spaced staggeringly apart from a second array comprising hollow "U"-shaped electrodes. Preferably a ratio between effective area of an electrode in the second array compared to effective area of an electrode in the first array exceeds about 15:1 and preferably is about 20:1. An electric field produced by the high voltage pulses between the arrays produces an electrostatic flow of ionized air containing safe amounts of ozone. The outflow of ionized air and ozone is directed between the brush bristles onto the hair and scalp being groomed.

29 Claims, 13 Drawing Sheets



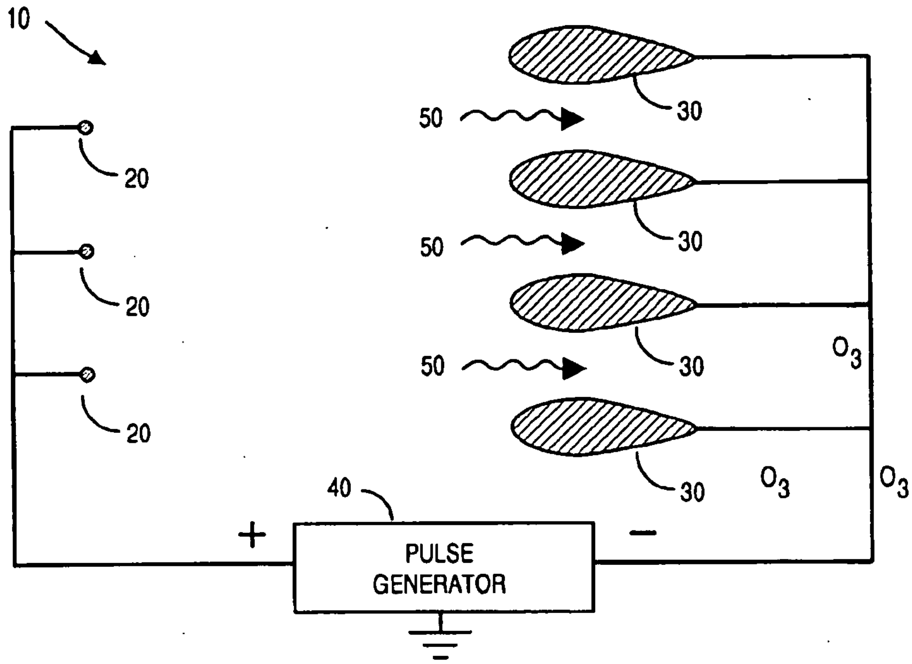


FIG. 1A (PRIOR ART)

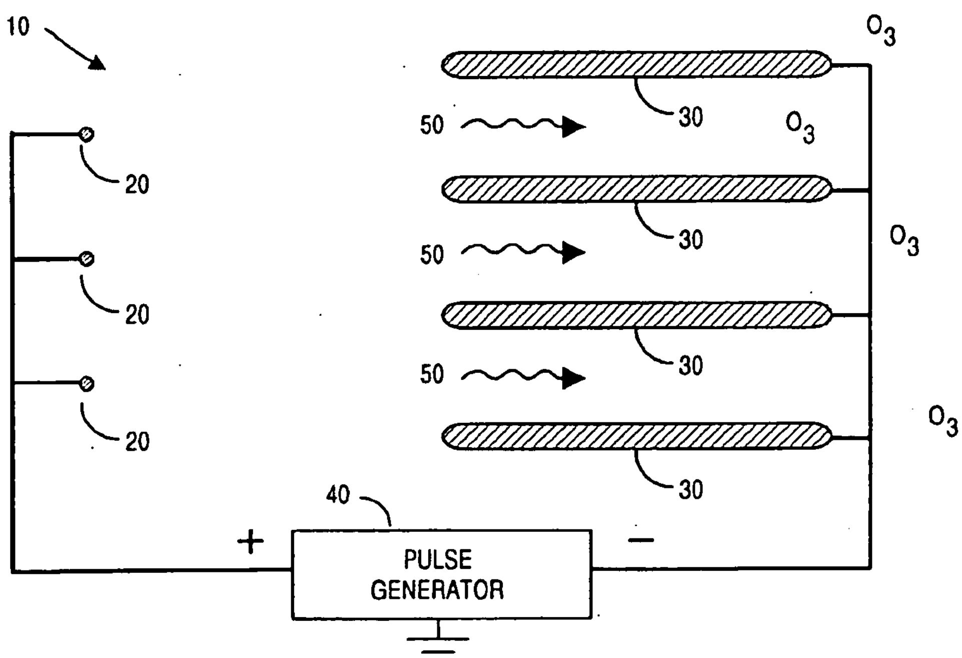


FIG. 1B (PRIOR ART)

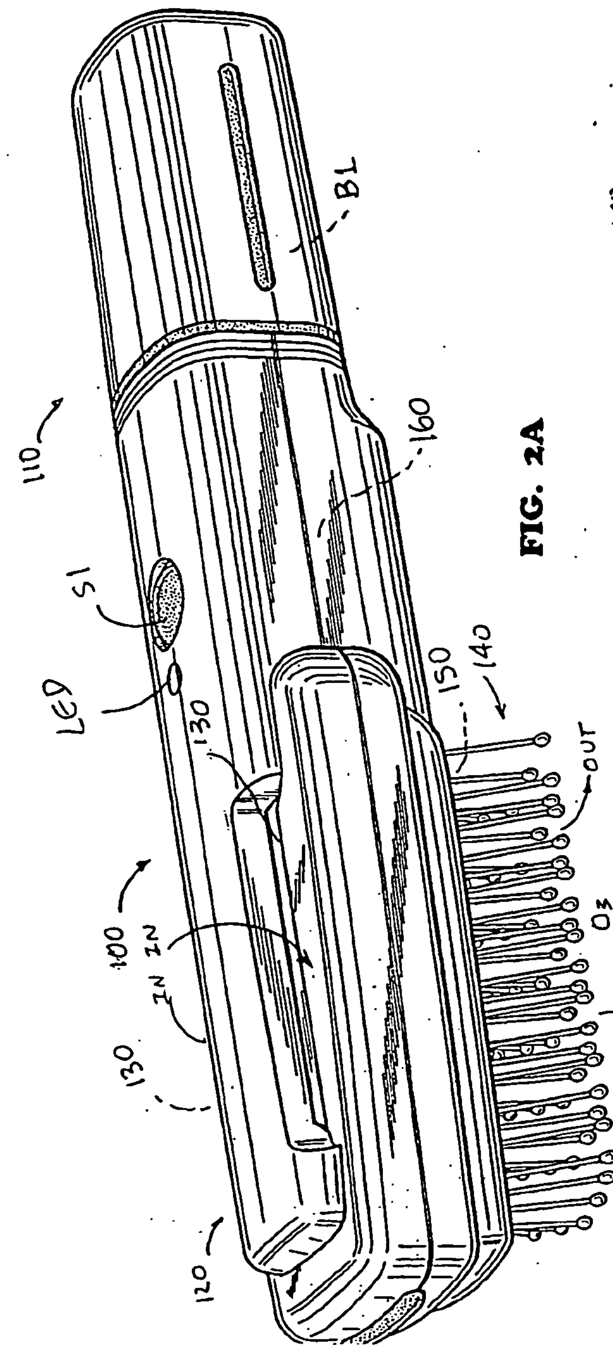

BL
160
110
S1
LED
130
100
IN IN
130
120
150
140
OUT
O3
OUT
O3

FIG. 2A

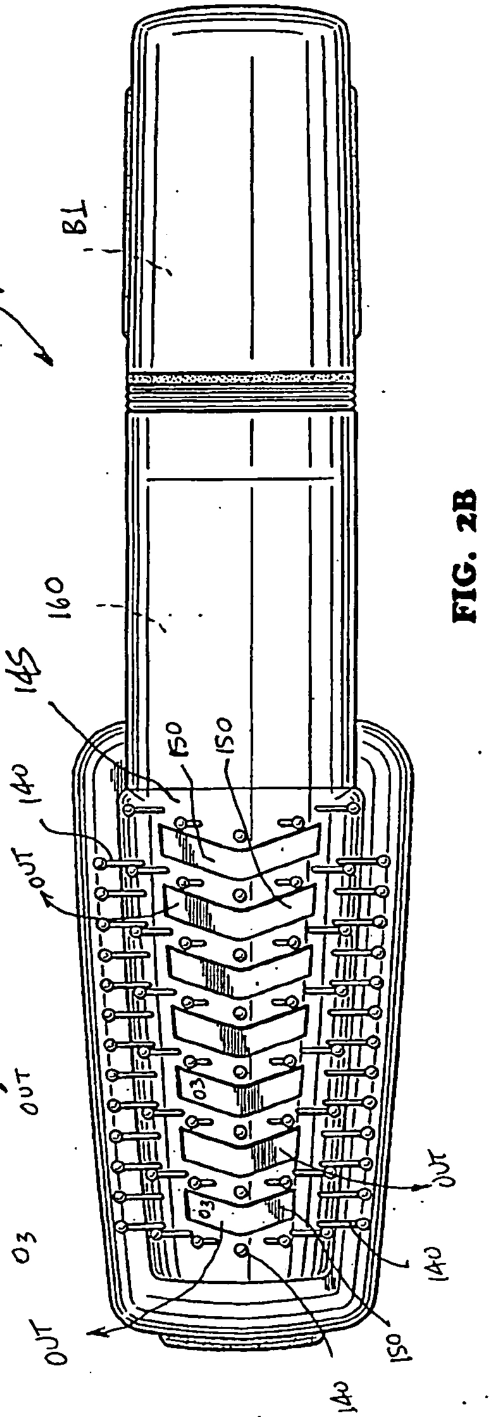

BL
100
160
145
150
150
140
OUT
O3
O3
OUT
140
OUT
140
150

FIG. 2B

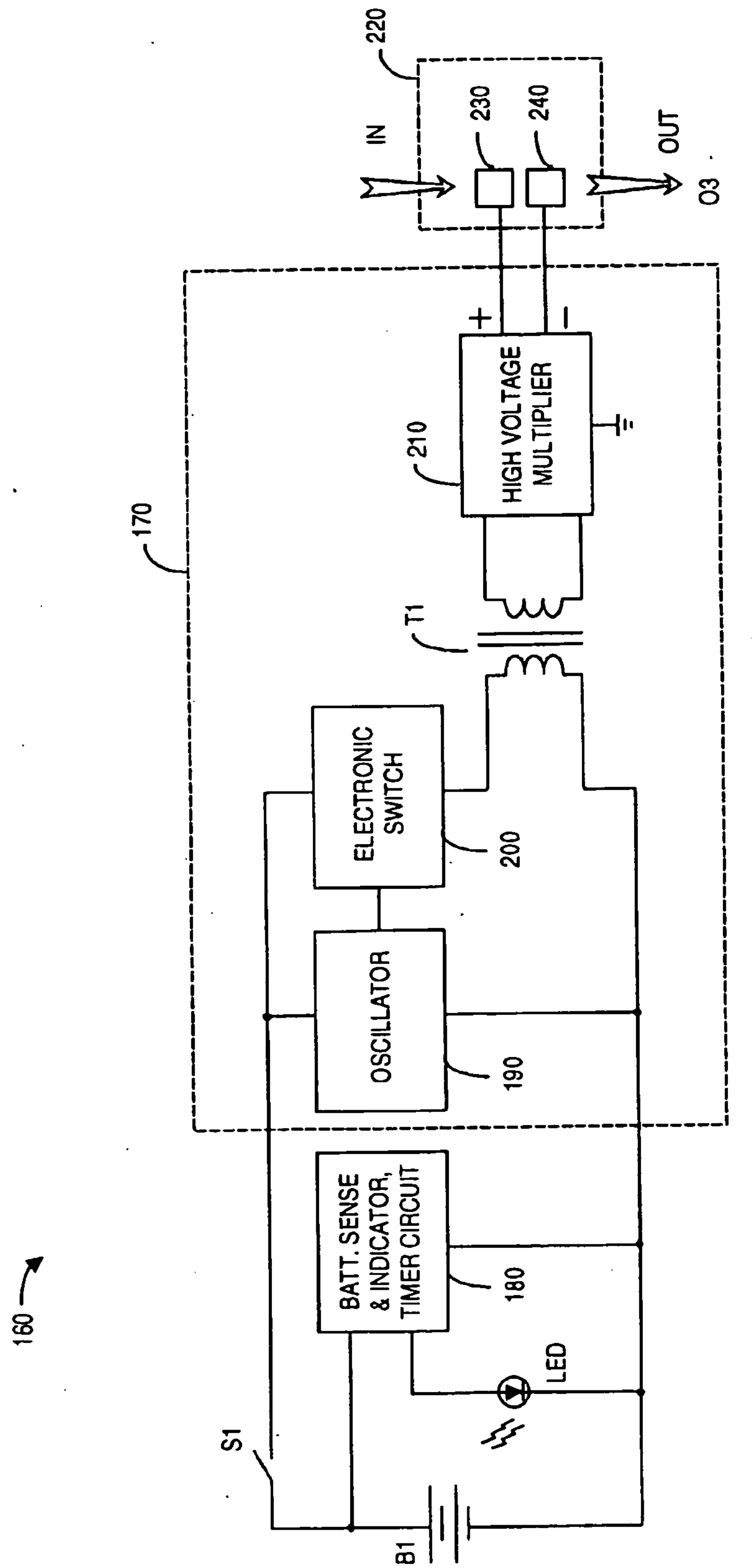

220
IN
230
240
OUT
O3
170
+
-
210
HIGH VOLTAGE MULTIPLIER
T1
ELECTRONIC SWITCH
200
OSCILLATOR
190
BATT. SENSE & INDICATOR, TIMER CIRCUIT
180
LED
160
S1
B1

FIG. 3

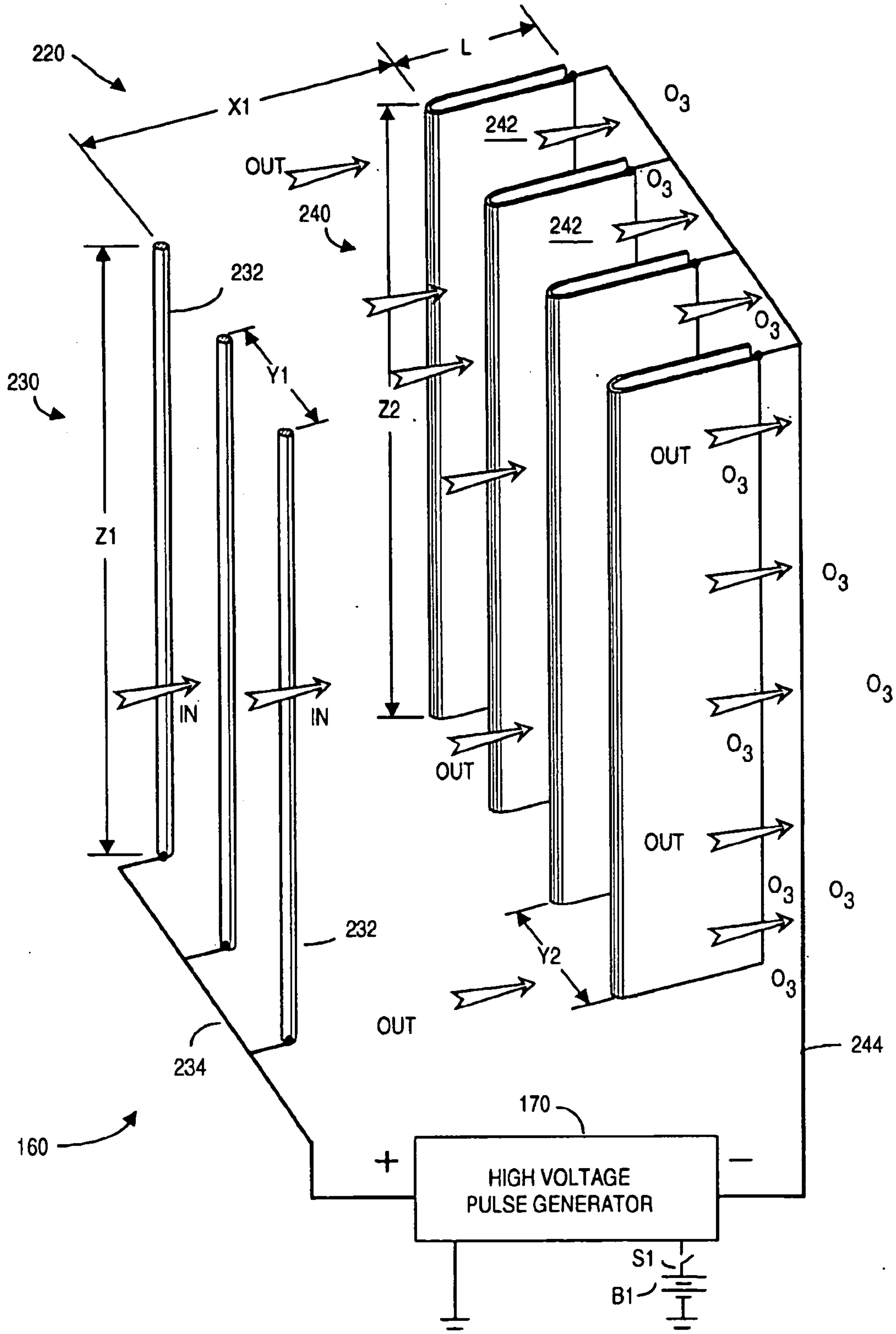

220
L
X1
O_3
242
OUT
240
242
232
230
Y1
Z2
Z1
OUT
IN
IN
OUT
OUT
232
Y2
OUT
234
244
170
160
+
HIGH VOLTAGE
PULSE GENERATOR
−
S1
B1

FIG. 4A

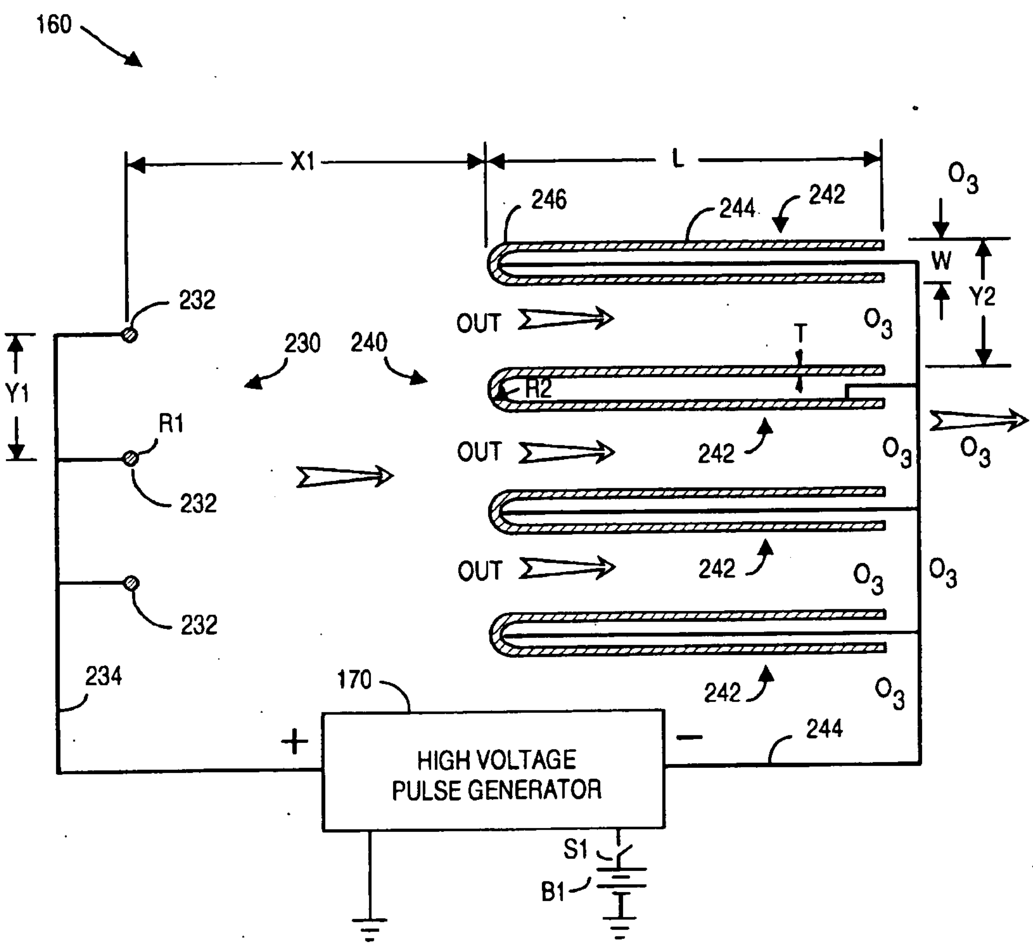

160
X1
L
246
244
242
O_3
W
Y2
232
Y1
230
240
OUT
O_3
T
R2
R1
232
OUT
242
O_3
O_3
OUT
242
O_3
O_3
232
234
170
242
O_3
244
+
−
HIGH VOLTAGE
PULSE GENERATOR
S1
B1

FIG. 4B

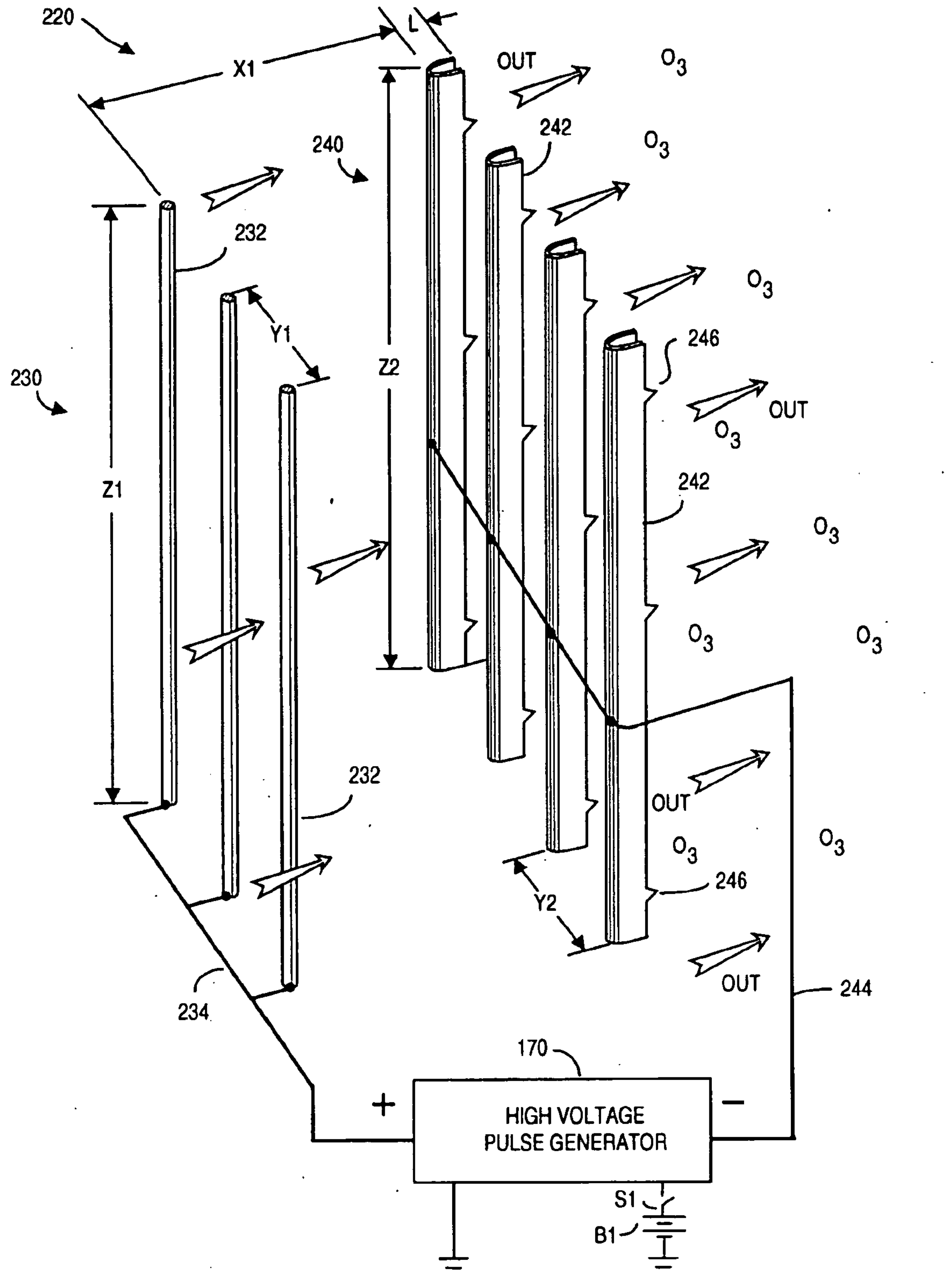

220
X1
L
OUT
O_3
240
242
232
Y1
230
Z2
246
OUT
Z1
242
232
OUT
Y2
246
OUT
234
244
170
+
HIGH VOLTAGE
PULSE GENERATOR
−
S1
B1

FIG. 4C

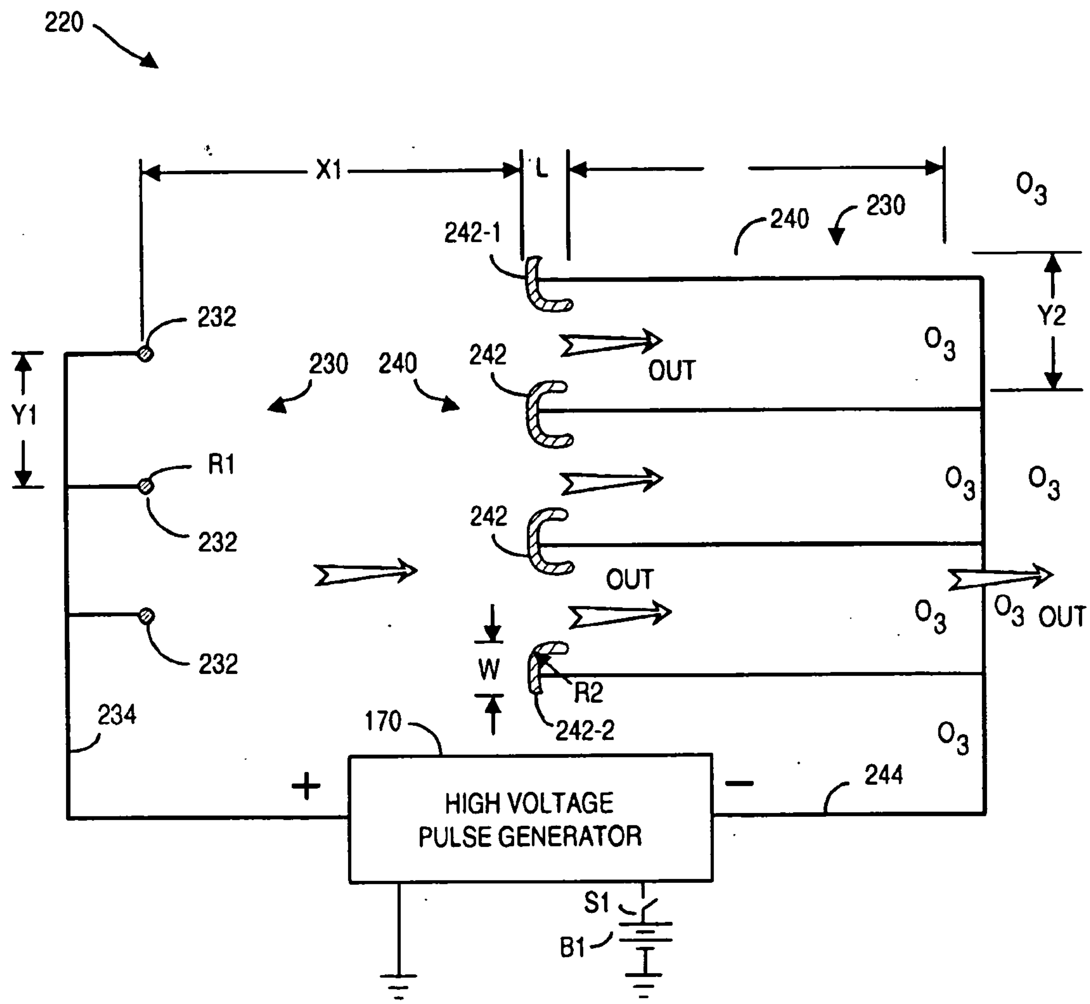

220
X1
L
240
230
242-1
O_3
Y2
232
230
240
242
OUT
O_3
Y1
R1
O_3
O_3
232
242
OUT
O_3
O_3 OUT
232
W
R2
242-2
234
170
O_3
244
+
−
HIGH VOLTAGE
PULSE GENERATOR
S1
B1

FIG. 4D

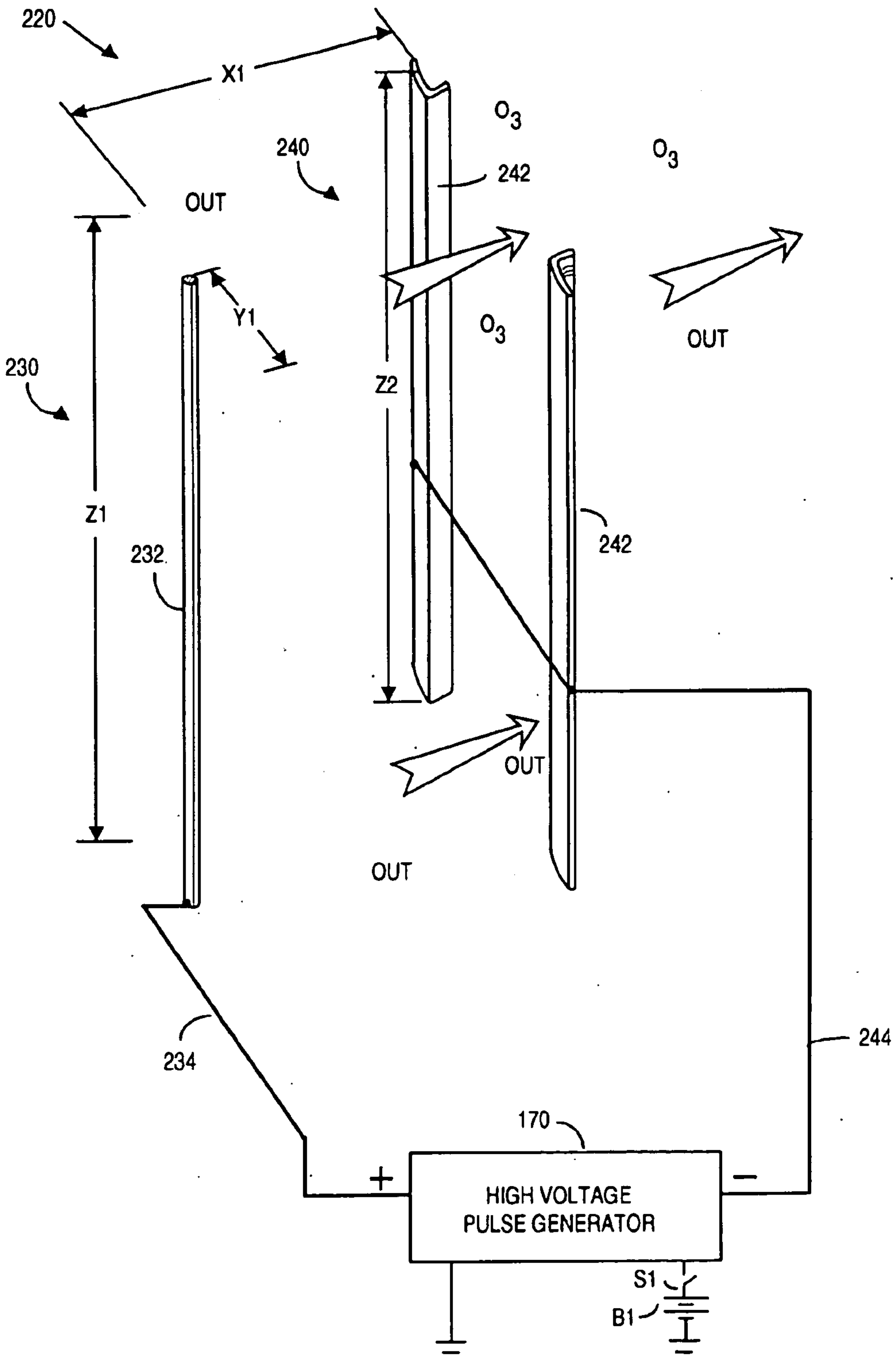

220
X1
O_3
O_3
240
242
OUT
230
Y1
Z2
O_3
OUT
Z1
232
242
OUT
OUT
234
244
170
+
−
HIGH VOLTAGE
PULSE GENERATOR
S1
B1

FIG. 4E

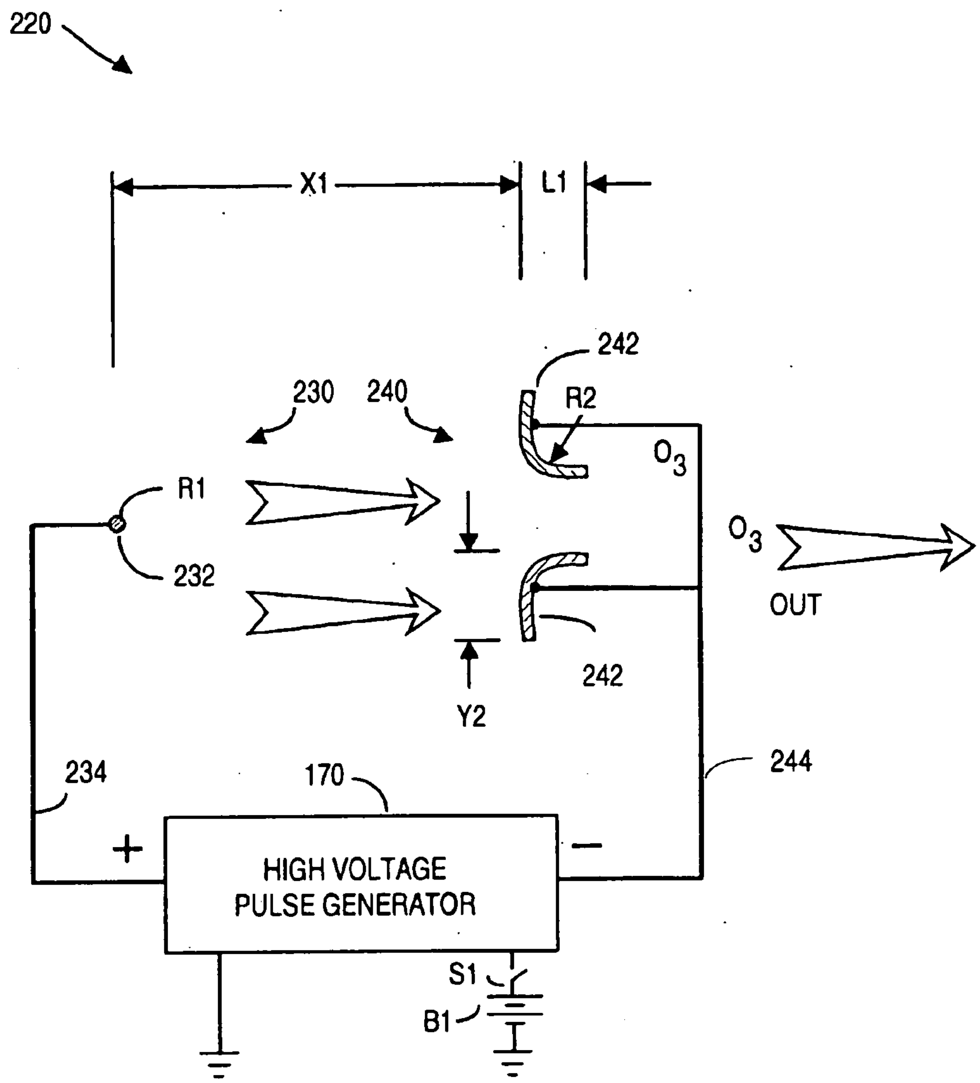

220
X1
L1
242
230
240
R2
O_3
R1
O_3
OUT
232
242
Y2
234
170
244
+
−
HIGH VOLTAGE
PULSE GENERATOR
S1
B1

FIG. 4F

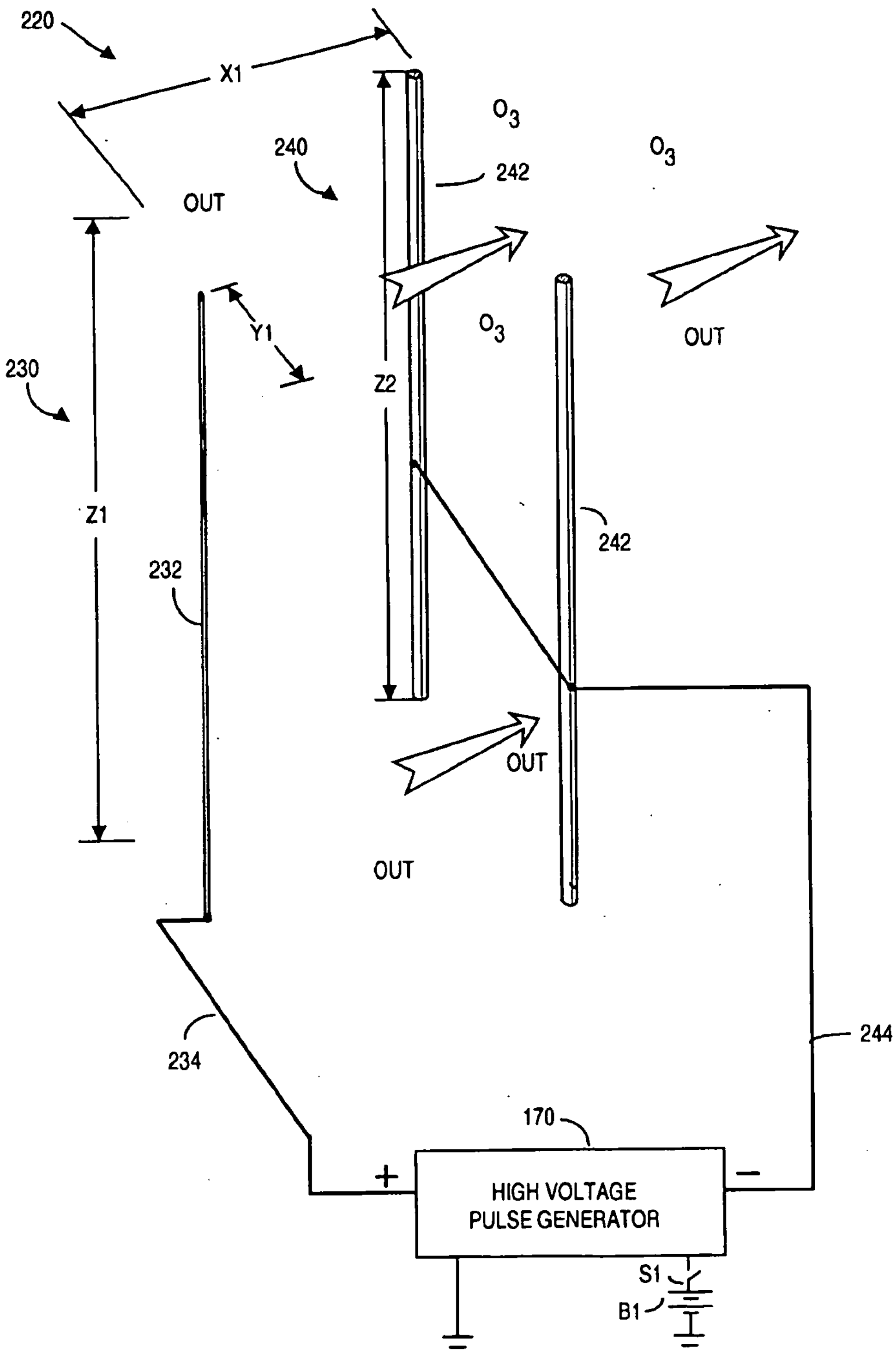

220
X1
240
242
O_3
O_3
OUT
O_3
OUT
230
Y1
Z2
Z1
242
232
OUT
OUT
244
234
170
HIGH VOLTAGE
PULSE GENERATOR
+
−
S1
B1

FIG. 4G

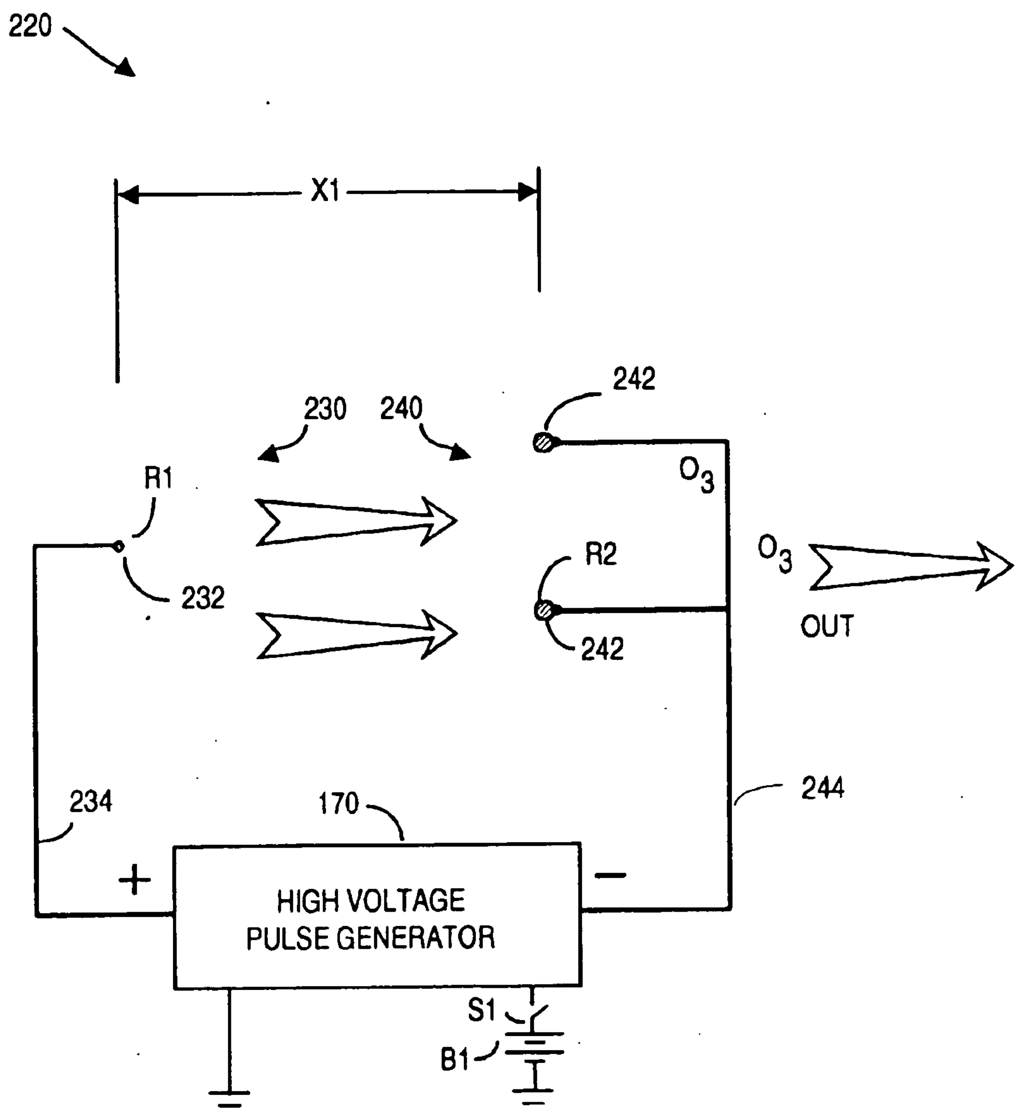

220
X1
230
240
242
R1
O_3
232
R2
O_3
242
OUT
234
170
244
+
−
HIGH VOLTAGE
PULSE GENERATOR
S1
B1

FIG. 4H

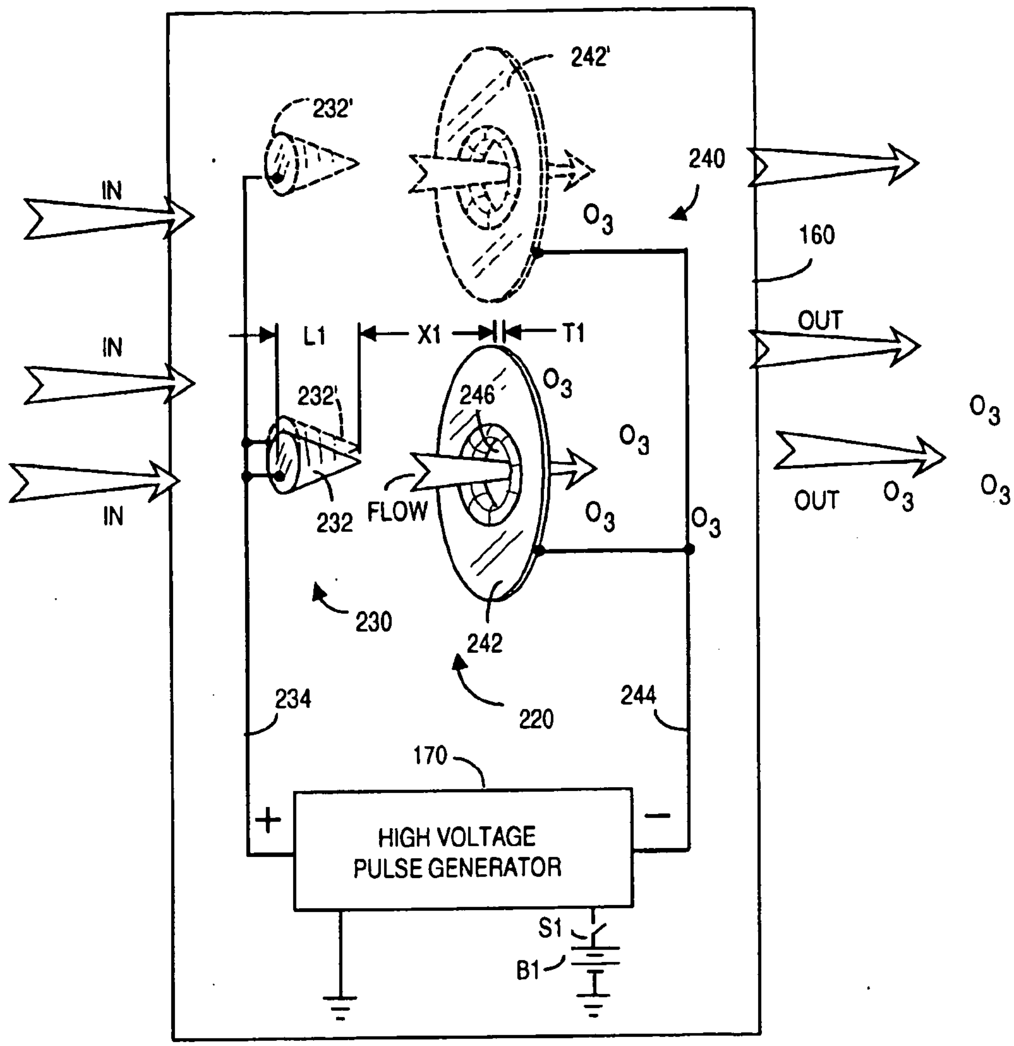


FIG. 4I

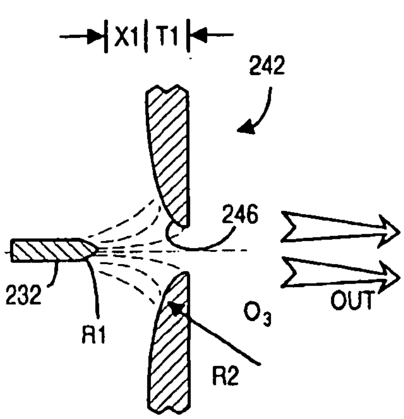


FIG. 4J

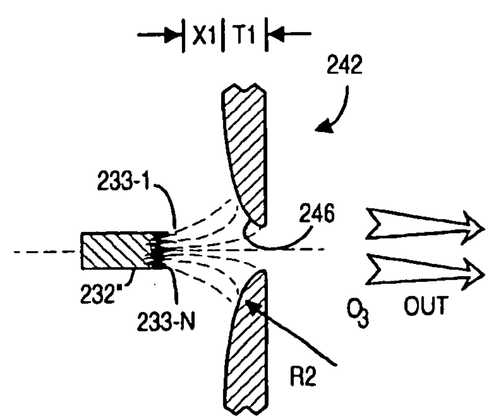


FIG. 4K

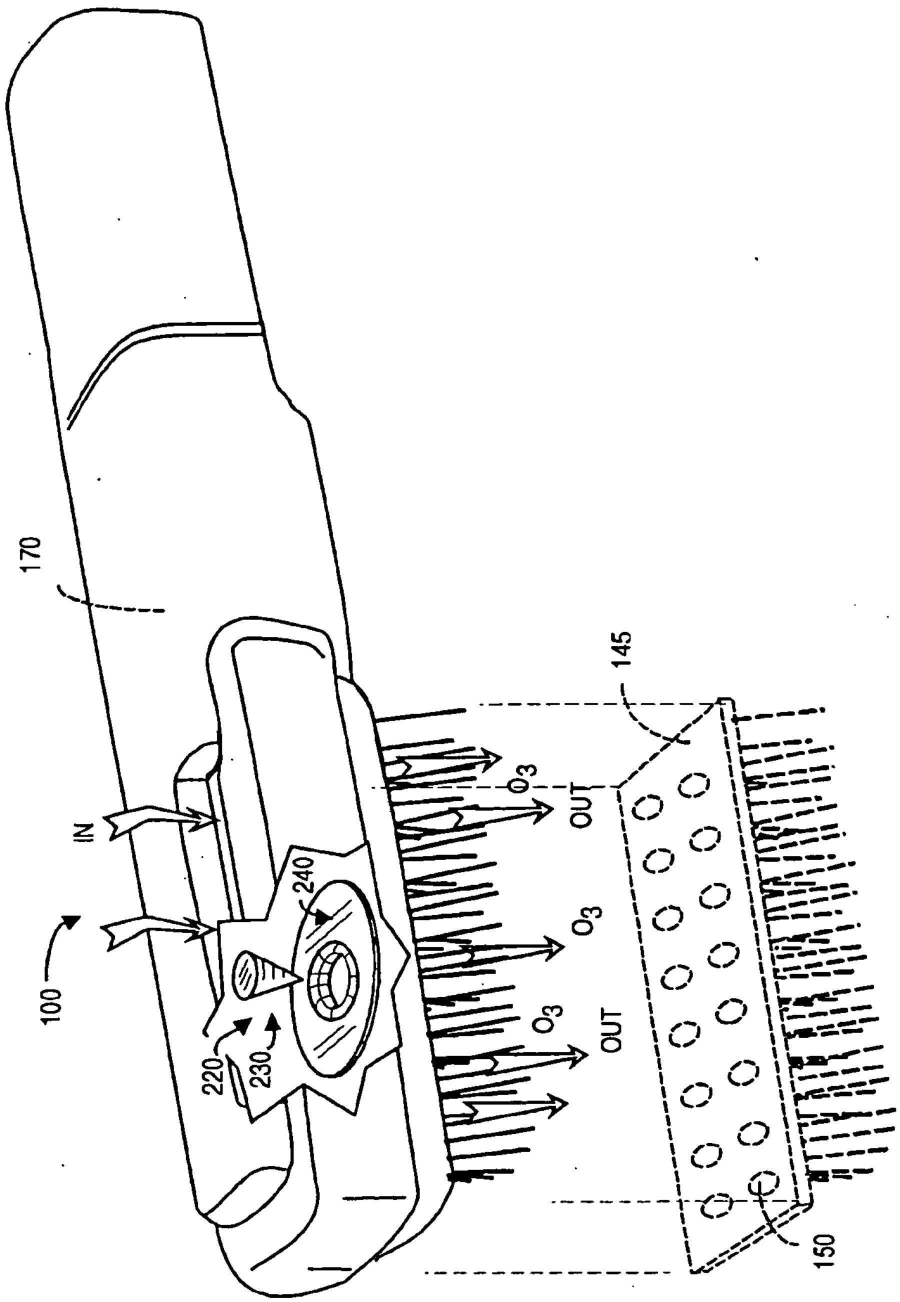


FIG. 5

ION EMITTING GROOMING BRUSH

FIELD OF THE INVENTION

This invention relates to grooming products such as hair brushes for humans and pets, and more specifically to hair brushes that promote grooming by emitting ionized air directed to the hairs being brushed.

BACKGROUND OF THE INVENTION

Hair brushes have been used for thousands of years in an attempt to groom hair. In the grooming process, bristles projecting from a hair brush are forced toward the scalp in an attempt to cause individual hairs to either fall into place, or to align with each other somewhat.

However common experience indicates that conventional hair brushing is not always successful. For example, individual hairs frequently refuse to closely align closely with each other. One explanation may be that scales on the individual hair shafts can project outward, which prevents adjacent hairs from being forced into close alignment; the projecting scales simply get in the way.

While hair brushing can be stimulating to the scalp, brushing per se does not always achieve a well groomed appearance, and accomplishes little or nothing with respect to cleaning or conditioning the hair. While sufficiently large foreign particles, e.g., dirt, dandruff, may be brushed out of the hair, smaller particles can remain in place on the hair shafts or hair scales. Brushing one's hair truly does not provide conditioning in that after brushing the hair frequently is as it was before, give or take some mechanical repositioning of the hairs.

It is known in the art to produce an air flow electro-kinetically by directly converting electrical power into a flow of air without mechanically moving components. One such system is described in U.S. Pat. No. 4,789,801 to Lee (1988), depicted herein in simplified form as FIGS. 1A and 1B. Lee's system **10** provides a first array of small area ("minisectional") electrodes **20** is spaced-apart symmetrically from a second array of larger area ("maxisectional") electrodes **30**, with a high voltage (e.g., 5 KV) pulse generator **40** coupled between the two arrays. Generator **40** outputs high voltage pulses that ionize the air between the arrays, producing an air flow **50** from the minisectional array toward the maxisectional array results. The high voltage field present between the two arrays can release ozone (O_3), which can advantageously safely destroy many types of bacteria if excessive quantities of ozone are not released.

Unfortunately, Lee's tear-shaped maxisectional electrodes are relatively expensive to fabricate, most likely requiring mold-casting or extrusion processes. Further, air flow and ion generation efficiency is not especially high using Lee's configuration.

There is a need for a hair brush that can not only brush hair, but provide a measure of cleaning and/or conditioning as well. Preferably such hair brush should subject the hair being brushed to an ion flow to promote cleaning and grooming.

The present invention provides such a grooming brush.

SUMMARY OF THE PRESENT INVENTION

The present invention provides a hair brush whose body includes a handle portion and a head portion defining at least one vent and including projecting bristles. More preferably, the head portion upperside will define at least one air intake vent and the head portion underside defines at least one ionized air outlet vent.

Contained within the hair brush body is a battery-operated ionizer unit with DC battery power supply. The ionizer unit includes a DC:DC inverter that boosts the battery voltage to high voltage, and a pulse generator that receives the high voltage DC and outputs high voltage pulses of perhaps 10 KV peak-to-peak, although high voltage DC could be used instead of pulses. The unit also includes an electrode assembly unit comprising first and second spaced-apart arrays of conducting electrodes, the first array and second array being coupled, respectively, preferably to the positive and negative output ports of the high voltage pulse generator.

The electrode assembly preferably is formed using first and second arrays of readily manufacturable electrode types. In one embodiment, the first array comprises wire-like electrodes and the second array comprises "U"-shaped electrodes having one or two trailing surfaces. In an even more efficient embodiment, the first array includes at least one pin or cone-like electrode and the second array is an annular washer-like electrode. The electrode assembly may comprise various combinations of the described first and second array electrodes. In the various embodiments, the ratio between effective area of the second array electrodes to the first array electrodes is at least about 20:1.

The high voltage pulses create an electric field between the first and second electrode arrays. This field produces an electro-kinetic airflow going from the first array toward the second array, the airflow being rich in ions and in ozone (O_3). Ambient air enters the hair brush head via air intake vent(s), and ionized air (with ozone) exits the hair brush through outlet vent(s) in the bristle portion of the head. However, in practice if only one vent is present, it suffices as both an intake and an outlet vent. Preferably a visual indicator is coupled to the ionizer unit to visually confirm to a user when the unit is ready for ionizing operation, and when ionization is actually occurring.

Hair brushed with the bristles is subjected to a gentle flow of ionized air from the outlet vent(s). The hair seems to fall more rapidly into place with a cleaner and more conditioned appearance, compared to hair groomed with an ordinary hair brush. The ozone emissions can kill many types of germs and bacteria that may be present on the hair and scalp and can deodorize the hair and scalp.

Other features and advantages of the invention will appear from the following description in which the preferred embodiments have been set forth in detail, in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A and 1B are depictions of Lee-type electrostatic generators, according to the prior art;

FIG. 2A is an perspective view of a preferred embodiment of an ionizing hair brush, according to the present invention;

FIG. 2B is a bottom view of a preferred embodiment of an ionizing hair brush, according to the present invention;

FIG. 3 is an electrical block diagram of the present invention;

FIG. 4A is a perspective block diagram showing a first embodiment for an electrode assembly, according to the present invention;

FIG. 4B is a plan block diagram of the embodiment of FIG. 4A;

FIG. 4C is a perspective block diagram showing a second embodiment for an electrode assembly, according to the present invention;

FIG. 4D is a plan block diagram of a modified version of the embodiment of FIG. 4C;

FIG. 4E is a perspective block diagram showing a third embodiment for an electrode assembly, according to the present invention;

FIG. 4F is a plan block diagram of the embodiment of FIG. 4E;

FIG. 4G is a perspective block diagram showing a fourth embodiment for an electrode assembly, according to the present invention;

FIG. 4H is a plan block diagram of the embodiment of FIG. 4G;

FIG. 4I is a perspective block diagram showing a fifth embodiment for an electrode assembly, according to the present invention;

FIG. 4J is a detailed cross-sectional view of a portion of the embodiment of FIG. 4I;

FIG. 4K is a detailed cross-sectional view of a portion of an alternative to the embodiment of FIG. 4I;

FIG. 5 is a cutaway perspective view of the present invention showing location of the electrode assembly, according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIGS. 2A and 2B depict an ionized hair brush **100** according to the present invention as having a body that includes a handle portion **110** and a head portion **120**. Head portion **120** includes one or more air intake vents **130**, brush bristles **140** that protrude from a brush plate **145** attached to the brushing surface of the hair brush, and one or more outlet vents **150**. Internal to the hair brush body is an ion generating unit **160**, powered by a battery **B1** (preferably at least 6 VDC) contained within the hair brush and energizable via a switch **S1**, preferably mounted on the hair brush **100**. As such, ion generating unit **160** is self-contained in that other than ambient air, nothing is required from beyond the body of the hair brush for operation of the present invention. Of course if desired, a DC power supply could be disposed external to the hair brush body, and power brought into the hair brush via a cable.

Preferably handle portion **110** is detachable from head portion **120**, to provide access to battery **B1**, preferably five NiCd rechargeable cells or four disposable cells. The housing material is preferably inexpensive, lightweight, and easy to fabricate, ABS plastic for example. Hair brush **100** is preferably approximately the size of typical hair brushes, for example an overall length of perhaps 235 mm, and a maximum width of perhaps 58 mm, although other dimensions can of course be used.

Brush plate **145** may be removably attached to hair brush **100**, for ease of cleaning the bristles, for providing access to an ion-emitting electrode assembly within the brush head, as well as for inserting a different brush plate bearing a different type of bristles. Thus, for reasons of hygiene different family members might use the same hair brush **100**, but with different sets of bristles that are interchangeable via different brush plates **145**. Alternatively, different types or shapes or configurations of bristles might be used interchangeably simply by inserting different brush plate-bristle assemblies into the head portion of the present invention.

It will also be appreciated that use of the present invention is not limited to grooming humans, and one could use the present invention to groom animals including household pets (e.g., dogs, cats). Thus, whereas bristles **140** might be fabricated from nylon or plastic for grooming human hair, the bristles might instead be metal when the hair brush is

used to groom animal fur. Thus, if desired, a brush plate **145** containing nylon bristles could be replaced with a different brush plate containing metal bristles for grooming the family cat.

The ability to remove brush plate **145** also provides ready access to electrodes within the brush head, for purposes of cleaning and, if necessary, replacement. It is to be understood that although FIGS. 2A and 2B depict an exemplary embodiment for hair brush **100**, other configurations may be used. Different configurations of inlet vent(s) **130** and/or outlet vent(s) **150** may be used. Thus, more or fewer such vents may be provided, the locations location and/or shapes of which may differ from what is depicted in FIGS. 2A and 2B. The purpose of vents **130** and **150** is to ensure that an adequate flow of ambient air may be drawn into or made available to unit **130**, and that an adequate flow of ionized air that includes safe amounts of O_3 flows out from unit **130** towards the grooming area.

As best seen in FIG. 3, ion generating unit **160** includes a high voltage pulse generator unit **170** and optionally an indicator circuit **180**. Circuit **180** senses potential on battery **B1** and indicates whether battery potential is sufficient to generate ions and when ion generation is occurring. In the preferred embodiment, a visual indicator is used, preferably a two-color light emitting diode ("LED"). Of course other indicator devices may be used, including for example, blinking indicator(s), and/or audible indicator(s). Optionally, circuit **180** includes timing components that will turn-off generation of ions and ozone after a predetermined time, for example two minutes. Such a turn-off feature will preserve battery lifetime in the event **S1** is other than a push-to-maintain contact type switch. Thus, a user who pushes **S1**, combs his or her hair (or grooms a pet), and forgets to turn-off S1 will not necessarily deplete battery **B1**, as circuitry **180** will turn-off the present invention for the user.

As shown in FIG. 3, high voltage pulse generator unit **170** preferably comprises a low voltage oscillator circuit **190** of perhaps 20 KHz frequency, that outputs low voltage pulses to an electronic switch **200**, e.g., a thyristor or the like. Switch **200** switchably couples the low voltage pulses to the input winding of a step-up transformer **T1**. The secondary winding of T1 is coupled to a high voltage multiplier circuit **210** that outputs high voltage pulses. Preferably the circuitry and components comprising high voltage pulse generator **170** and sense/indicator circuit (and timing circuit) **180** are fabricated on a printed circuit board that is mounted within head portion **120** of hair brush **100**.

Output pulses from high voltage generator **170** preferably are at least 10 KV peak-to-peak with an effective DC offset of perhaps half the peak-to-peak voltage, and have a frequency of perhaps 20 KHz. The pulse train output preferably has a duty cycle of perhaps 10%, which will promote battery lifetime. Of course, different peak-peak amplitudes, DC offsets, pulse train waveshapes, duty cycle, and/or repetition frequencies may instead be used. Indeed, a 100% pulse train (e.g., an essentially DC high voltage) may be used, albeit with shorter battery lifetime.

Frequency of oscillation is not especially critical but, frequency of at least about 20 KHz is preferred as being inaudible to humans. However if brush **100** is intended for use in grooming pets, even higher operating frequency may be desired such that the present invention does not emit audible sounds that would disturb an animal being groomed with the brush.

The output from high voltage pulse generator unit **170** is coupled to an electrode assembly **220** that comprises a first

electrode array **230** and a second electrode array **240**. Unit **170** functions as a DC:DC high voltage generator, and could be implemented using other circuitry and/or techniques to output high voltage pulses that are input to electrode assembly **220**.

In the embodiment of FIG. **3**, the positive output terminal of unit **170** is coupled to first electrode array **230**, and the negative output terminal is coupled to second electrode array **240**. This coupling polarity has been found to work well. An electrostatic flow of air is created, going from the first electrode array towards the second electrode array. (This flow is denoted "OUT" in the figures.) Accordingly electrode assembly **220** is mounted in the head portion **120** of hair brush **100** such that second electrode array **240** is closer to the brushing surface (e.g., bristle-containing region where outlet vent(s) **150** are located) than is first electrode array **230**.

When voltage or pulses from high voltage pulse generator **170** are coupled across first and second electrode arrays **230** and **240**, it is believed that a plasma-like field is created surrounding electrodes **232** in first array **230**. This electric field ionizes the air between the first and second electrode arrays and establishes an "OUT" airflow that moves towards the second array. It is understood that the IN flow enters brush **100** via vent(s) **130**, and that the OUT flow exits brush **100** via vent(s) **150**.

It is believed that ozone and ions are generated simultaneously by the first array electrode(s) **232**, essentially as a function of the potential from generator **170** coupled to the first array. Ozone generation may be increased or decreased by increasing or decreasing the potential at the first array. Coupling an opposite polarity potential to the second array electrode(s) **242** essentially accelerates the motion of ions generated at the first array, producing the air flow denoted as "OUT" in the figures. As the ions move toward the second array, it is believed that they push or move air molecules toward the second array. The relative velocity of this motion may be increased by decreasing the potential at the second array relative to the potential at the first array.

For example, if +10 KV were applied to the first array electrode(s), and no potential were applied to the second array electrode(s), a cloud of ions (whose net charge is positive) would form adjacent the first electrode array. Further, the relatively high 10 KV potential would generate substantial ozone. By coupling a relatively negative potential to the second array electrode(s), the velocity of the air mass moved by the net emitted ions increases, as momentum of the moving ions is conserved.

On the other hand, if it were desired to maintain the same effective outflow (OUT) velocity but to generate less ozone, the exemplary 10 KV potential could be divided between the electrode arrays. For example, generator **170** could provide +6 KV (or some other fraction) to the first array electrode(s) and –4 KV (or some other fraction) to the second array electrode(s). In this example, it is understood that the +6 KV and the –4 KV are measured relative to ground. Understandable it is desired that the present invention operate to output safe amounts of ozone.

As noted, outflow (OUT) preferably includes safe amounts of O_3 that can destroy or at least substantially alter bacteria, germs, and other living (or quasi-living) matter subjected to the outflow. Thus, when switch **S1** is closed and **B1** has sufficient operating potential, pulses from high voltage pulse generator unit **170** create an outflow (OUT) of ionized air and O_3. When S1 is closed, LED will first visually signal whether sufficient B1 potential is present, and if present, then signal when ionization is occurring. If LED fails to indicate sufficient operating voltage, the user will know to replace **B1** or, if rechargeable cells are used, to recharge **B1**. For example, if visual indicator is a two-color device, the LED could signal red when B1 potential exceeds a minimum threshold, e.g., 5.5 VDC. Further, LED could then signal green when S1 is depressed and unit **160** is actually outputting ionized air. If the battery potential is too low, the LED will not light, which advises the user to replace or re-charge battery source **B1**.

Preferably operating parameters of the present invention are set during manufacture and are not user-adjustable. For example, increasing the peak-to-peak output voltage and/or duty cycle in the high voltage pulses generated by unit **170** can increase air flowrate, ion content, and ozone content. In the preferred embodiment, output flowrate is about 90 feet/minute, ion content is about 2,000,000/cc and ozone content is about 50 ppb (over ambient) to perhaps 2,000 ppb (over ambient). Decreasing the R2/R1 ratio below about 20:1 will decrease flow rate, as will decreasing the peak-to-peak voltage and/or duty cycle of the high voltage pulses coupled between the first and second electrode arrays.

In practice, a user holds and uses hair brush **100** in conventional fashion to brush hair. With **S1** energized, ionization unit **160** emits ionized air and preferably some ozone (O_3) via outlet vents **150**. The hair being groomed advantageously is subjected to this outflow ("OUT") of air and ozone. Beneficially, the brushed air seems to align together more coherently than when using a non-ionized brush. The explanation possibly is that electrically charged ions in the outflow cause scales on individual hair shafts to lie more closely against the shaft, rather than project outwardly to prevent adjacent hairs from closely aligning. In general, the hair will appear more groomed.

Odors in the hair and scalp being brushed will diminish, and some types of germs or bacteria, if present, can be killed by the outflow from hair brush **100**. In short, not only is the hair brushed and groomed more effectively than with a passive prior art brush, e.g., a brush that does not actively emit ions, but hygiene is promoted as well.

Having described various aspects of the invention in general, preferred embodiments of electrode assembly **220** will now be described. In the various embodiments, electrode assembly **220** will comprise a first array **230** of at least one electrode **232**, and will further comprise a second array **240** of preferably at least one electrode **242**. Understandably material(s) for electrodes **232** and **242** should conduct electricity, be resilient to corrosive effects from the application of high voltage, yet be strong enough to be cleaned.

In the various electrode assemblies to be described herein, electrode(s) **232** in the first electrode array **230** are preferably fabricated from tungsten. Tungsten is sufficiently robust to withstand cleaning, has a high melting point to retard breakdown due to ionization, and has a rough exterior surface that seems to promote efficient ionization. On the other hand, electrodes **242** preferably will have a highly polished exterior surface to minimize unwanted point-to-point radiation. As such, electrodes **242** preferably are fabricated from stainless steel, brass, among other materials. The polished surface of electrodes **232** also promotes ease of electrode cleaning.

In contrast to the prior art electrodes disclosed by Lee, electrodes **232** and **242** according to the present invention are light weight, easy to fabricate, and lend themselves to mass production. Further, electrodes **232** and **242** described herein promote more efficient generation of ionized airs and production of safe amounts of ozone, O_3.

In the present invention, a high voltage pulse generator 170 is coupled between the first electrode array 230 and the second electrode array 240. The high voltage pulses produce a flow of ionized air that travels in the direction from the first array towards the second array (indicated herein by hollow arrows denoted "OUT"). As such, electrode(s) 232 may be referred to as an emitting electrode, and electrodes 242 may be referred to as collector electrodes. This outflow advantageously contains safe amounts of O_3, and exits the present invention from vent(s) 150, as shown in FIGS. 2A and 2B. Although a generator of high voltage pulses is preferred and will promote battery life, in practice high voltage DC (e.g., pulses having 100% duty cycle) may instead be used.

According to the present invention, it is preferred that the positive output terminal or port of the high voltage pulse generator be coupled to electrodes 232, and that the negative output terminal or port be coupled to electrodes 242. It is believed that the net polarity of the emitted ions is positive, e.g., more positive ions than negative ions are emitted. In any event, the preferred electrode assembly electrical coupling minimizes audible hum from electrodes 232 contrasted with reverse polarity (e.g., interchanging the positive and negative output port connections). Further, the preferred electrical coupling seems to produce ions that help keep hair in place, as opposed to putting ~~a static charge~~ into the hair that can produce an undesired "fly-away" hair appearance. In some embodiments, however, one port (preferably the negative port) of high voltage pulse generator may in fact be the ambient air. Thus, electrodes in the second array need not be connected to the high voltage pulse generator using wire. Nonetheless, there will be an "effective connection" between the second array electrodes and one output port of the high voltage pulse generator, in this instance, via ambient air.

Turning now to the embodiments of FIGS. 4A and 4B, electrode assembly 220 comprises a first array 230 of wire electrodes 232, and a second array 240 of generally "U"-shaped electrodes 242. In preferred embodiments, the number N1 of electrodes comprising the first array will differ by one relative to the number N2 of electrodes comprising the second array. In many of the embodiments shown, N2>N1. However, if desired, in FIG. 4A, addition first electrodes 232 could be added at the out ends of array 230 such that N1>N2, e.g., five electrodes 232 compared to four electrodes 242.

Electrodes 232 are preferably lengths of tungsten wire, whereas electrodes 242 are formed from sheet metal, preferably stainless steel, although brass or other sheet metal could be used. The sheet metal is readily formed to define side regions 244 and bulbous nose region 246 for hollow elongated "U" shaped electrodes 242. While FIG. 4A depicts four electrodes 242 in second array 240 and three electrodes 232 in first array 230, as noted, other numbers of electrodes in each array could be used, preferably retaining a symmetrically staggered configuration as shown.

As best seen in FIG. 4B, the spaced-apart configuration between the arrays is staggered such that each first array electrode 232 is substantially equidistant from two second array electrodes 242. This symmetrical staggering has been found to be an especially efficient electrode placement. Preferably the staggering geometry is symmetrical in that adjacent electrodes 232 or adjacent electrodes 242 are spaced-apart a constant distance, Y1 and Y2 respectively. However, a non-symmetrical configuration could also be used, although ion emission and air flow would likely be diminished. Also, it is understood that the number of electrodes 232 and 242 may differ from what is shown.

In FIGS. 4A, typically dimensions are as follows: diameter of electrodes 232 is about 0.08 mm, distances Y1 and Y2 are each about 16 mm, distance X1 is about 16 mm, distance L is about 20 mm, and electrode heights Z1 and Z2 are each about 100 mm. The width W of electrodes 242 is preferably about 4 mm, and the thickness of the material from which electrodes 242 are formed is about 0.5 mm. Of course other dimensions and shapes could be used. It is preferred that electrodes 232 be small in diameter to help establish a desired high voltage field. On the other hand, it is desired that electrodes 232 (as well as electrodes 242) be sufficiently robust to withstand occasional cleaning.

Electrodes 232 in first array 230 are coupled by a conductor 234 to a first (preferably positive) output port of high voltage pulse generator 170, and electrodes 242 in second array 240 are coupled by a conductor 244 to a second (preferably negative) output port of generator 170. It is relatively unimportant where on the various electrodes electrical connection is made to conductors 234 or 244. Thus, by way of example FIG. 4B depicts conductor 244 making connection with some electrodes 242 internal to bulbous end 246, while other electrodes 242 make electrical connection to conductor 244 elsewhere on the electrode. Electrical connection to the various electrodes 242 could also be made on the electrode external surface providing no substantial impairment of the outflow airstream results.

The ratio of the effective electric field emanating area of electrode 232 to the nearest effective area of electrodes 242 is at least about 15:1, and preferably is at least 20:1. Beyond a ratio of say 35:1, little or no performance improvement results. Thus, in the embodiment of FIG. 4A and FIG. 4B, the ratio R2/R1=2 mm/0.08 mm=25:1.

In this and the other embodiments to be described herein, ionization appears to occur at the smaller electrode(s) 232 in the first electrode array 230, with ozone production occurring as a function of high voltage arcing. For example, increasing the peak-to-peak voltage amplitude and/or duty cycle of the pulses from the high voltage pulse generator 170 can increase ozone content in the output flow of ionized air.

In the embodiment of FIGS. 4A and 4C, each "U"-shaped electrode 242 has two trailing edges 244 that promote efficient kinetic transport of the outflow of ionized air and O_3. By contrast, the embodiments of FIGS. 4C and 4D depict somewhat truncated versions of electrodes 242. Whereas dimension L in the embodiment of FIGS. 4A and 4B was about 20 mm, in FIGS. 4C and 4D, L has been shortened to about 8 mm. Other dimensions in FIG. 4C preferably are similar to those stated for FIGS. 4A and 4B. In FIGS. 4C and 4D, the inclusion of point-like regions 246 on the trailing edge of electrodes 242 seems to promote more efficient generation of ionized air flow. It will be appreciated that the configuration of second electrode array 240 in FIG. 4C can be more robust than the configuration of FIGS. 4A and 4B, by virtue of the shorter trailing edge geometry. As noted earlier, a symmetrical staggered geometry for the first and second electrode arrays is preferred for the configuration of FIG. 4C.

In the embodiment of FIG. 4D, the outermost second electrodes, denoted 242-1 and 242-2, have substantially no outermost trailing edges. Dimension L in FIG. 4D is preferably about 3 mm, and other dimensions may be as stated for the configuration of FIGS. 4A and 4B. Again, the R2/R1 ratio for the embodiment of FIG. 4D preferably exceeds about 20:1.

FIGS. 4E and 4F depict another embodiment of electrode assembly 220, in which the first electrode array comprises a single wire electrode 232, and the second electrode array comprises a single pair of curved "L"-shaped electrodes 242,

in cross-section. Typical dimensions, where different than what has been stated for earlier-described embodiments, are X1≈12 mm, Y1≈6 mm, Y2≈3 mm, and L1≈3 mm. The effective R2/R1 ratio is again greater than about 20:1. The fewer electrodes comprising assembly **220** in FIGS. **4E** and **4F** promote economy of construction, and ease of cleaning, although more than one electrode **232**, and more than two electrodes **242** could of course be employed. This embodiment again incorporates the staggered symmetry described earlier, in which electrode **232** is equidistant from two electrodes **242**.

FIG. **4G** and **4H** shown yet another embodiment for electrode assembly **220**. In this embodiment, first electrode array **230** is a length of wire **232**, while the second electrode array **240** comprises a pair of rod or columnar electrodes **242**. As in embodiments described earlier herein, it is preferred that electrode **232** be symmetrically equidistant from electrodes **242**. Wire electrode **232** is preferably perhaps 0.08 mm tungsten, whereas columnar electrodes **242** are perhaps 2 mm diameter stainless steel. Thus, in this embodiment the R2/R1 ratio is about 25:1. Other dimensions may be similar to other configurations, e.g., FIG. **4E**, **4F**. Of course electrode assembly **220** may comprise more than one electrode **232**, and more than two electrodes **242**.

An especially preferred embodiment is shown in FIG. **4I** and FIG. **4J**. In these figures, the first electrode assembly comprises a single pin-like element **232** disposed coaxially with a second electrode array that comprises a single ring-like electrode **242** having a rounded inner opening **246**. However, as indicated by phantom elements **232'**, **242'**, electrode assembly **220** may comprise a plurality of such pin-like and ring-like elements. Preferably electrode **232** is tungsten, and electrode **242** is stainless steel.

Typical dimensions for the embodiment of FIG. **4I** and FIG. **4J** are L1≈10 mm, X1≈9.5 mm, T≈0.5 mm, and the diameter of opening **246** is about 12 mm. Dimension L1 preferably is sufficiently long that upstream portions of electrode **232** (e.g., portions to the left in FIG. **4I**) do not interfere with the electrical field between electrode **232** and the collector electrode **242**. However, as shown in FIG. **4J**, the effect R2/R1 ratio is governed by the tip geometry of electrode **232**. Again, in the preferred embodiment, this ratio exceeds about 20:1. Lines drawn in phantom in FIG. **4J** depict theoretical electric force field lines, emanating from emitter electrode **232**, and terminating on the curved surface of collector electrode **246**. Preferably the bulk of the field emanates within about ±45° of coaxial axis between electrode **232** and electrode **242**. On the other hand, if the opening in electrode **242** and/or electrode **232** and **242** geometry is such that too narrow an angle about the coaxial axis exists, air flow will be unduly restricted.

One advantage of the ring-pin electrode assembly configuration shown in FIG. **4I** is that the flat regions of ring-like electrode **242** provide sufficient surface area to which dust entrained in the moving air stream can attach, yet be readily cleaned. As a result, the air stream (OUT) emitted by the hair brush has reduced dust content especially contrasted to prior art kinetic air mover configurations.

Further, the ring-pin configuration advantageously generates more ozone than prior art configurations, or the configurations of FIGS. **4A–4H**. For example, whereas the configurations of FIGS. **4A–4H** may generate perhaps 50 ppb ozone, the configuration of FIG. **4I** can generate about 2,000 ppb ozone, without an increase in demand upon power supply **B1**.

Nonetheless it will be appreciated that applicants' first array pin electrodes may be utilized with the second array electrodes of FIGS. **4A–4H**. Further, applicants' second array ring electrodes may be utilized with the first array electrodes of FIGS. **4A–4H**. For example, in modifications of the embodiments of FIGS. **4A–4H**, each wire or columnar electrode **232** is replaced by a column of electrically series-connected pin electrodes (e.g., as shown in FIGS. **4I–4K**), while retaining the second electrode arrays as depicted in these figures. By the same token, in other modifications of the embodiments of FIGS. **4A–4H**, the first array electrodes can remain as depicted, but each of the second array electrodes **242** is replaced by a column of electrically series-connected ring electrodes (e.g., as shown in FIGS. **4I–4K**).

In FIG. **4J**, a detailed cross-sectional view of the central portion of electrode **242** in FIG. **4I** is shown. As best seen in FIG. **4J**, curved region **246** adjacent the central opening in electrode **242** appears to provide an acceptably large surface area to which many ionization paths from the distal tip of electrode **232** have substantially equal path length. Thus, while the distal tip (or emitting tip) of electrode **232** is advantageously small to concentrate the electric field between the electrode arrays, the adjacent regions of electrode **242** preferably provide many equidistant inter-electrode array paths. A high exit flowrate of perhaps 90 feet/minute and 2,000 ppb range ozone emission attainable with this configuration confirm a high operating efficiency.

In FIG. **4K**, one or more electrodes **232** is replaced by a conductive block **232"** of carbon fibers, the block having a distal surface in which projecting fibers **233-1**, . . . **233-*N*** take on the appearance of a "bed of nails". The projecting fibers can each act as an emitting electrode and provide a plurality of emitting surfaces. Over a period of time, some or all of the electrodes will literally be consumed, whereupon graphite block **232"** will be replaced. Materials other than graphite may be used for block **232"** providing the material has a surface with projecting conductive fibers such as **233-*N***.

FIG. **5** depicts the location of a typical electrode assembly **220** within the head portion of hair brush **100**, such that second electrode array **240** is closer to the brushing surface of the hair brush than is first electrode array **230**. While FIG. **5** depicts an electrode assembly **220** using the ring-pin configuration of FIG. **4I**, it is understood that any of the alternative configurations of FIGS. **4A–4G** could instead be contained within hair brush **100**. FIG. **5** also depicts the optionally removable nature of bristle block **145**, and a different configuration of exit vents **150**.

Preferably the inner portion of the head region of brush **100** includes an electrostatic shield that reduces detectable electromagnetic radiation outside of the brush. For example, a metal shield could be disposed within the housing, or portions of the interior of the housing could be coated with a metallic paint to reduce such radiation.

It will also be appreciated that the net output of ions could be influenced by placing a bias element near some or all of the output vents. For example, such an element could be electrically biased to neutralize negative ions, thereby increasing the net output of positive ions. It will also be appreciated that the present invention could be adjusted to produce ions without producing ozone, if desired.

Modifications and variations may be made to the disclosed embodiments without departing from the subject and spirit of the invention as defined by the following claims.

What is claimed is:

1. A self-contained ion emitting hair brush, comprising:

a hair brush having a body that includes a head brushing portion from which bristles emerge, said body defining at least one vent; and

a self-contained ion generator, disposed within said body, including:

a high voltage generator outputting a signal whose duty cycle can be about 10% to about 100%; and

an electrode assembly comprising a first electrode array effectively coupled to a first output port of said generator, and a second electrode array effectively coupled to a second output port of said generator, wherein one said output port may be at a same potential as ambient air;

said first electrode array including at least one electrode selected from a group consisting of an electrically conductive tapered pin-shaped electrode, and an electrically conductive material having ends defining a plurality of projecting conductive fibers; and

said second electrode array including an electrically conductive electrode selected from a group consisting of a ring-shaped electrode defining a central through opening, and a loop-shaped electrode defining a central through opening; said second electrode being disposed coaxial with and in a downstream direction from a projecting end of an electrode in said first electrode array;

said ion generator producing at least one of ionized air that flows electrostatically from said at least one vent toward an object brushed with said bristles and ozone that flows electrostatically from said at least one vent toward an object brushed with said bristles.

2. The hair brush of claim 1, wherein said hair brush includes at least one feature selected from a group consisting of:

(a) said body defines at least one inlet vent through which air to be ionized enters said body, and

(b) said hair brush includes a bristle block to which said bristles are attached, said bristle block being removably attachable to said head brushing portion of said body.

3. The hair brush of claim 1, wherein said high voltage generator has a characteristic selected from a group consisting of (a) said high voltage generator provides a first potential, measurable relative to ground, to said first electrode array and provides a second potential, measurable relative to ground, to said second electrode array, and (b) said high voltage generator provides a first positive potential, measurable relative to ground, to said first electrode array and provides a second negative potential, measurable relative to ground, to said second electrode array.

4. The hair brush of claim 1, wherein:

said first electrode array includes at least one said pin-shaped electrode, and said second electrode array has at least one characteristic selected from a group consisting of (i) said loop-shaped electrode defines in cross-section a tapered region terminating towards said central through opening, (ii) said loop-shaped electrode defines in cross-section a rounded region terminating towards said central through opening, (c) said loop-shaped electrode defines in cross-section a rounded profile terminating in said through opening, (d) a ratio of effective radius of said loop-shaped electrode to effective radius of said pin-shaped electrode exceeds about 15:1, (e) said pin-shaped electrode includes tungsten, (f) said pin-shaped electrode includes stainless steel, (g) said pin-shaped electrode includes projecting fibers of carbon and (h) said loop-shaped electrode includes stainless steel.

5. The hair brush of claim 1, wherein said first electrode array includes at least one said pin-shaped electrode, and said second electrode array has at least one characteristic

selected from a group consisting of (i) said ring-shaped electrode defines in cross-section a tapered region terminating towards said central through opening, (ii) said ring-shaped electrode defines in cross-section a rounded region terminating towards said central through opening, (c) said ring-shaped electrode defines in cross-section a rounded profile terminating in said through opening, (d) a ratio of effective radius of said ring-shaped electrode to effective radius of said pin-shaped electrode exceeds about 15:1, (e) said pin-shaped electrode includes tungsten, (f) said pin-shaped electrode includes stainless steel, (g) said pin-shaped electrode includes projecting fibers of carbon, and (h) said ring-shaped electrode includes stainless steel.

6. A self-contained ion emitting hair brush, comprising:

a hair brush having a body that includes a head brushing portion from which bristles emerge, said body defining at least one vent; and

a self-contained ion generator, disposed within said body, including:

a high voltage generator outputting a signal whose duty cycle may be varied from about 10% to about 100%; and

an electrode assembly comprising a first electrode array effectively coupled to a first output port of said generator, and a second electrode array effectively coupled to a second output port of said generator, wherein one said output port may be at a same potential as ambient air;

said first electrode array including at least one metal wire electrode; and

said second electrode array including at least two electrically conductive electrodes each having a curved region facing said metal wire electrode and being equidistant therefrom, each of said electrically conductive electrodes defining in cross-section a shape selected from a group consisting of (a) a "U"-shape having a bulbous nose region that faces said metal wire electrode, (b) an "L"-shape having a curved nose region that faces said metal wire electrode, and (c) a circular-like shape having a curved region that faces said metal wire, said electrodes being rod-like in form;

said ion generator producing at least one of ionized air that flows electrostatically from said at least one vent toward an object brushed with said bristles and ozone that flows electrostatically from said at least one vent toward an object brushed with said bristles.

7. The hair brush of claim 6, wherein:

in cross-section each of said electrodes in said second array define said "L"-shape having a curved nose region; and

a ratio of radius of one said curved nose region to radius of said wire electrode exceeds about 15:1.

8. The hair brush of claim 6, wherein:

in cross-section each of said electrodes in said second array define said "U"-shape having a bulbous nose region and further includes a first trailing edge region and a second trailing edge region; and

an electrode in said second electrode array has at least one characteristic selected from a group consisting of (i) a portion of one said trailing edge region is longer than a remaining said trailing edge region on said electrode, and (ii) a said trailing edge region defines at least one pointed projection facing downstream.

9. The hair brush of claim 6, wherein:

said second electrode array includes at least two said electrically conductive electrodes that in cross-section define a "U"-shape having a bulbous nose region; and

a ratio of effective radius of an electrode in said second electrode array to effective radius of a said metal wire electrode in said first electrode array exceeds about 15:1.

10. The hair brush of claim 6, wherein:

said second electrode array includes at least two said rod-like electrically conductive electrodes; and

a ratio of radius of one of said rod-like electrodes to radius of said wire electrode exceeds about 15:1.

11. The hair brush of claim 6, wherein:

said high voltage generator has a characteristic selected from a group consisting of (a) said high voltage generator provides a first potential, measurable relative to around, to said first electrode array and provides a second potential, measurable relative to ground, to said second electrode array, and (b) said high voltage generator provides a first positive potential, measurable relative to ground, to said first electrode array and provides a second negative potential, measurable relative to ground, to said second electrode array.

12. A self-contained ozone emitting hair brush, comprising:

a hair brush having a body that includes a head brushing portion from which bristles emerge, said body defining at least one vent; and

a self-contained ozone generator, disposed within said body, comprising a high voltage generator outputting a signal whose duty cycle may be about 10% to about 100%;

an electrode assembly comprising a first electrode array effectively coupled to a first output port of said generator, and a second electrode array effectively coupled to a second output sort of said generator, wherein one said output port may be at a same potential as ambient air;

said first electrode array including at least one electrically conductive pin-shaped electrode having a tapered free end;

said second electrode array including an electrode comprising a loop of electrically conductive metal defining a central through opening, said second electrode being disposed coaxial with and in a downstream direction from said tapered free end of said at least one electrically conductive pin-shaped electrode, and said second electrode defining in cross-section a curved region terminating towards said central through opening;

said ozone generator producing ozone that flows in a downstream direction electrostatically from said at least one vent toward an object brushed with said bristles.

13. The hair brush of claim 12, wherein said ozone generator further outputs ionized air that flows electrostatically from said at least one vent toward an object brushed with said bristles.

14. The hair brush of claim 12, wherein:

said first electrode array includes a plurality of electrically conducting projections.

15. The hair brush of claim 12, wherein a ratio of effective radius of said electrode comprising a loop of electrically conductive metal to effective radius of said pin-shaped electrode exceeds about 15:1.

16. A self-contained ion emitting hair brush, comprising:

a hair brush having a body that includes a head brushing portion from which bristles emerge, said body defining at least one vent; and

a self-contained ion generator, disposed within said body, including:

a high voltage generator outputting a signal whose duty cycle may be varied from about 10% to about 100%; and

an electrode assembly comprising a first electrode array effectively coupled to a first output port of said generator, and a second electrode array effectively coupled to a second output port of said generator, wherein one said output port may be at a same potential as ambient air;

said first electrode array including at least one metal wire electrode; and

said second electrode array including at least two electrically conductive electrodes each having a curved region facing said metal wire electrode and being equidistant therefrom, each of said electrically conductive electrodes defining in cross-section a shape selected from a group consisting of (a) a "U"-shape having a bulbous nose region that faces said metal wire electrode, (b) an "L"-shape having a curved nose region that faces said metal wire electrode, and (c) a circular-like shape having a curved region that faces said metal wire, said electrodes being rod-like in form;

said ion generator producing at least one of ionized air that flows electrostatically from said at least one vent toward an object brushed with said bristles and ozone that flows electrostatically from said at least one vent toward an object brushed with said bristles.

17. The hair brush of claim 16, wherein:

in cross-section each of said electrodes in said second array define said "L"-shape having a curved nose region; and

a ratio of radius of one said curved nose region to radius of said wire electrode exceeds about 15:1.

18. The hair brush of claim 16, wherein:

in cross-section each of said electrodes in said second array define said "U"-shape having a bulbous nose region and further includes a first trailing edge region and a second trailing edge region; and

an electrode in said second electrode array has at least one characteristic selected from a group consisting of (i) a portion of one said trailing edge region is longer than a remaining said trailing edge region on said electrode, and (ii) a said trailing edge region defines at least one pointed projection facing downstream.

19. The hair brush of claim 16, wherein:

said second electrode array includes at least two said electrically conductive electrodes that in cross-section define a "U"-shape having a bulbous nose region; and

a ratio of effective radius of an electrode in said second electrode array to effective radius of a said metal wire electrode in said first electrode array exceeds about 15:1.

20. The hair brush of claim 16, wherein:

said second electrode array includes at least two said rod-like electrically conductive electrodes; and

a ratio of radius of one of said rod-like electrodes to radius of said wire electrode exceeds about 15:1.

21. A self-contained ion and ozone emitting hair brush, comprising:

a hair brush having a body that includes a head brushing portion from which bristles emerge, said body defining at least one vent;

a high voltage generator, disposed within said body, and outputting high voltage pulses having a duty cycle of about 15% to about 100%;

an electrode array, disposed within said body, comprising;

at least one electrically conductive pin-shaped electrode electrically coupled to a first output port of said pulse generator; and

at least one electrically conductive electrode defining a central through opening, having a shaped selected from a group consisting of a ring-shaped electrode and a loop-shaped electrode, and being electrically coupled to a second output port of said pulse generator, said second electrode being disposed coaxial with and in a downstream direction from a tapered end of said pin-shaped electrode;

wherein when operating potential is provided to said generator, said electrode array produces ionized air that flows electrostatically from said pin-shaped electrode toward said ring-shaped electrode, such that air exiting said at least one vent includes ions and ozone and flows toward an object brushed with said bristles.

22. The hair brush of claim **21**, further including a removable bristle block retaining said bristles.

23. The hair brush of claim **21**, wherein said electrode assembly has at least one characteristic selected from a group consisting of (i) said pin-shaped electrode includes tungsten, (ii) said pin-shaped electrode includes stainless steel, (iii) said pin-shaped electrode includes a plurality of projecting fibers of carbon, and (iv) a ratio of effective radius of said electrode defining a through opening to effective radius of said pin-shaped electrode exceeds about 15:1.

24. The hair brush of claim **21**, further including:

a battery, disposed within said body;

circuitry, coupleable to said battery, to signal at least one condition selected from a group consisting of (i) whether said battery has a voltage low enough to require replacement of said battery, (ii) whether said battery has sufficient voltage to operate said high voltage generator, and (iii) whether said electrode assembly is generating ions.

25. A method of subjecting hair being groomed with a hair brush to a flow of ionized air containing ozone, the method comprising:

providing a hair brush with a body that includes a hair brushing surface from which bristles emerge;

attaching to said body an ion generator including, within said body:

an electrode assembly comprising a first electrode array and a second electrode array; said first electrode array including at lease one electrically conductive tapered pin-shaped electrode, and said second electrode array including an electrically conductive electrode, selected from a group consisting of a ring-shaped electrode and a loop-shaped electrode, defining a central through opening and being electrically coupled to a second output port of said generator, said second electrode being disposed coaxial with and in a downstream direction from a tapered end of said tapered pin-shaped electrode; and

a high voltage generator having a first output port electrically coupled to said first electrode array, and having a second output port electrically coupled to said second electrode array, wherein one said port may be at a potential of ambient air;

said ion generator ionizing and electrostatically moving at least some ambient air through said hair brushing surface, the ionized air including ozone;

wherein said hair is subjected to a flow of ionized air including ozone.

26. The method of claim **25**, further including providing said electrically conductive electrode with a cross-section that defines a rounded region terminating towards said central through opening.

27. The method of claim **25**, wherein:

a ratio of effective radius of said electrically conductive electrode to effective radius of said pin-shaped electrode exceeds about 15:1.

28. The method of claim **25**, further including:

disposing a battery within said body; and

coupling to said battery circuitry to signal at least one condition selected from a group consisting of (i) whether said battery has a voltage low enough to require replacement of said battery, (ii) whether said battery has sufficient voltage to operate said high voltage generator, and (iii) whether said electrode assembly is generating ions.

29. The method of claim **25**, further including:

providing said high voltage generator with a characteristic selected from a group consisting of (a) said high voltage generator provides a first potential, measurable relative to ground, to said first electrode array and provides a second potential, measurable relative to ground, to said second electrode array, and (b) said high voltage generator provides a first positive potential, measurable relative to ground, to said first electrode array and provides a second negative potential, measurable relative to ground, to said second electrode array.

* * * * *

US006588434B2

(12) **United States Patent**
Taylor et al.

(10) **Patent No.: US 6,588,434 B2**
(45) **Date of Patent: *Jul. 8, 2003**

(54) **ION EMITTING GROOMING BRUSH**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **10/188,668**

(22) Filed: **Jul. 2, 2002**

(65) **Prior Publication Data**

US 2002/0174876 A1 Nov. 28, 2002

Related U.S. Application Data

(63) Continuation of application No. 09/742,814, filed on Dec. 19, 2000, which is a continuation of application No. 09/415,576, filed on Oct. 8, 1999, now Pat. No. 6,182,671, which is a continuation of application No. 09/163,024, filed on Sep. 29, 1998, now Pat. No. 5,975,090.

(51) **Int. Cl.**[7] **A45D 19/16**
(52) **U.S. Cl.** **132/116**; 132/154; 132/272; 15/104.002; 607/79
(58) **Field of Search** 132/112, 116, 132/148, 152, 154, 271, 272; 15/104.002, 246.3, 344, 345, 39.5, 40; 607/79

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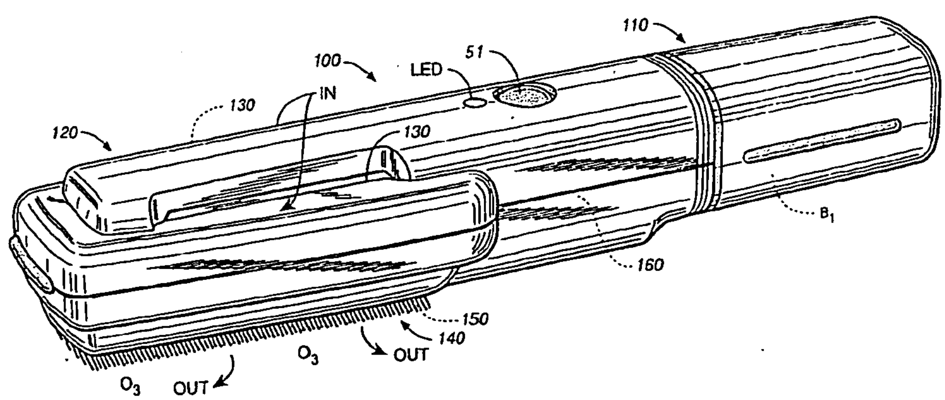
(57) **ABSTRACT**

A brush includes a self-contained ion generator that subjects material being brushed to an outflow of ionized air containing safe amounts of ozone. The ion generator includes a high voltage pulse generator whose output pulses are coupled between first and second electrode arrays. Preferably the first array comprises at least one metal pin spaced coaxially-apart from a metal ring-like structure. Alternatively, the first array may comprise one or more wire electrodes spaced staggeringly apart from a second array comprising hollow "U"-shaped electrodes. Preferably a ratio between effective area of an electrode in the second array compared to effective area of an electrode in the first array exceeds about 15:1 and preferably is about 20:1. An electric field produced by the high voltage pulses between the arrays produces an electrostatic flow of ionized air containing safe amounts of ozone. The outflow of ionized air and ozone is directed between the brush bristles onto the material being brushed.

45 Claims, 13 Drawing Sheets



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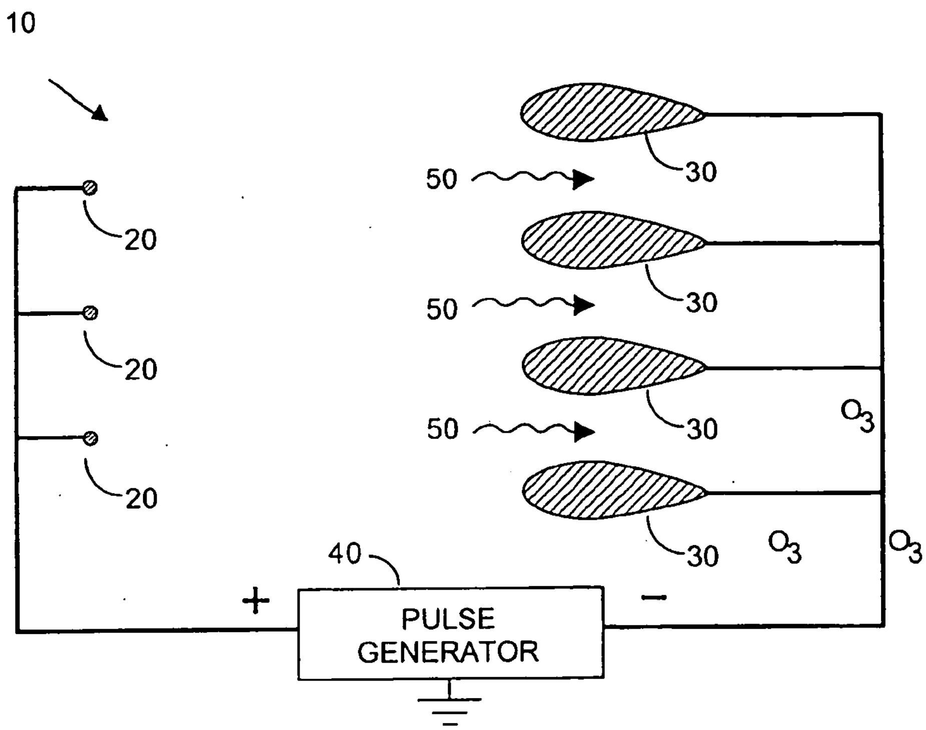


FIG. 1A (PRIOR ART)

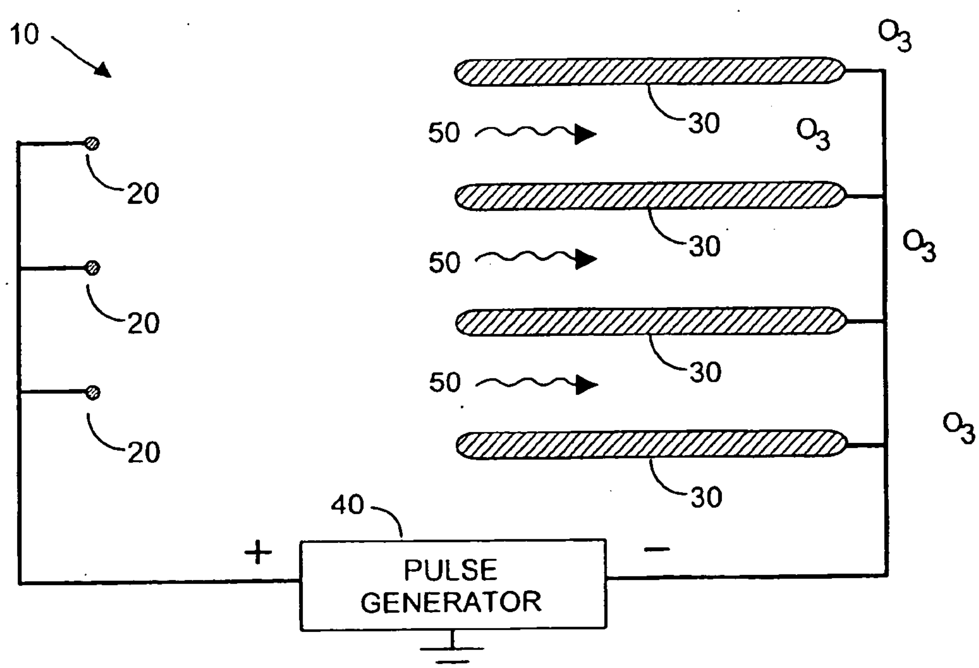
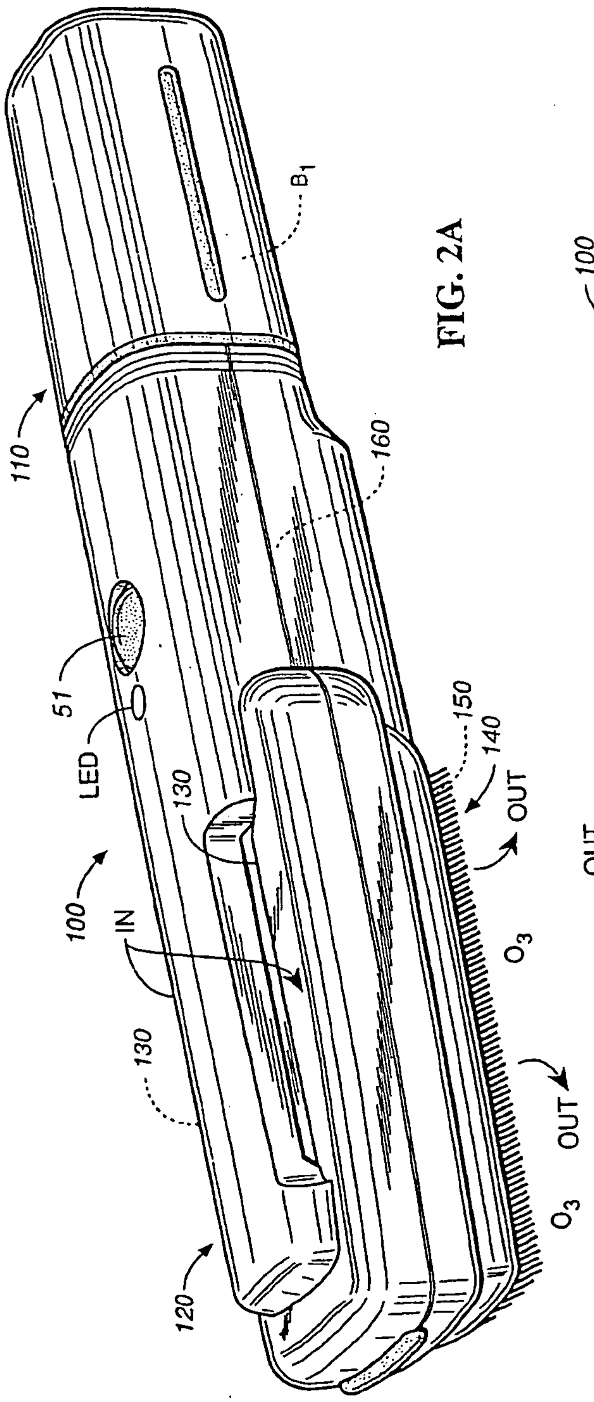
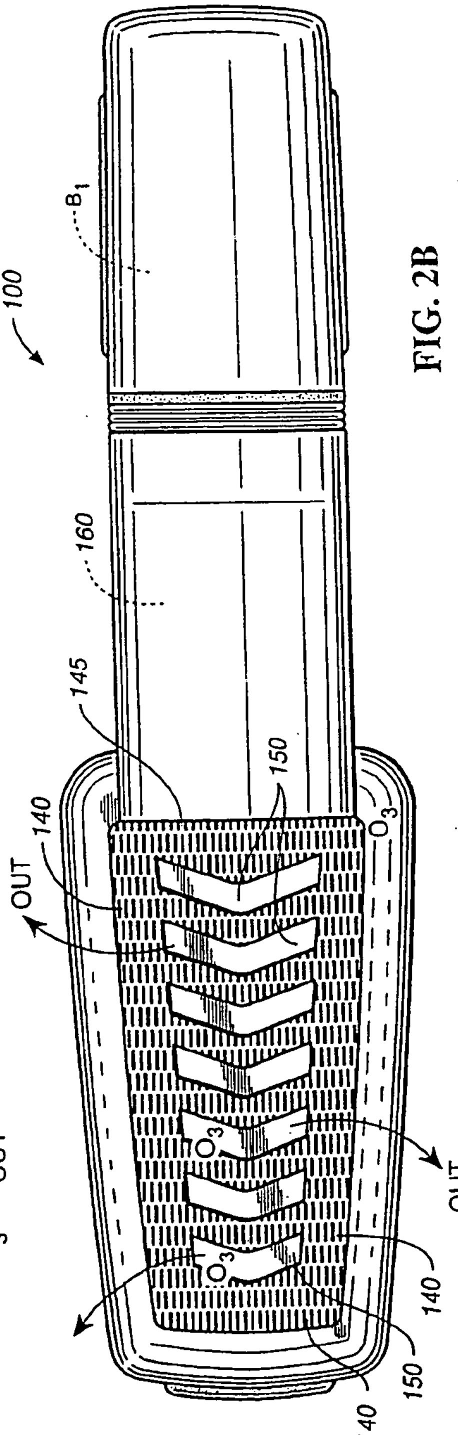


FIG. 1B (PRIOR ART)



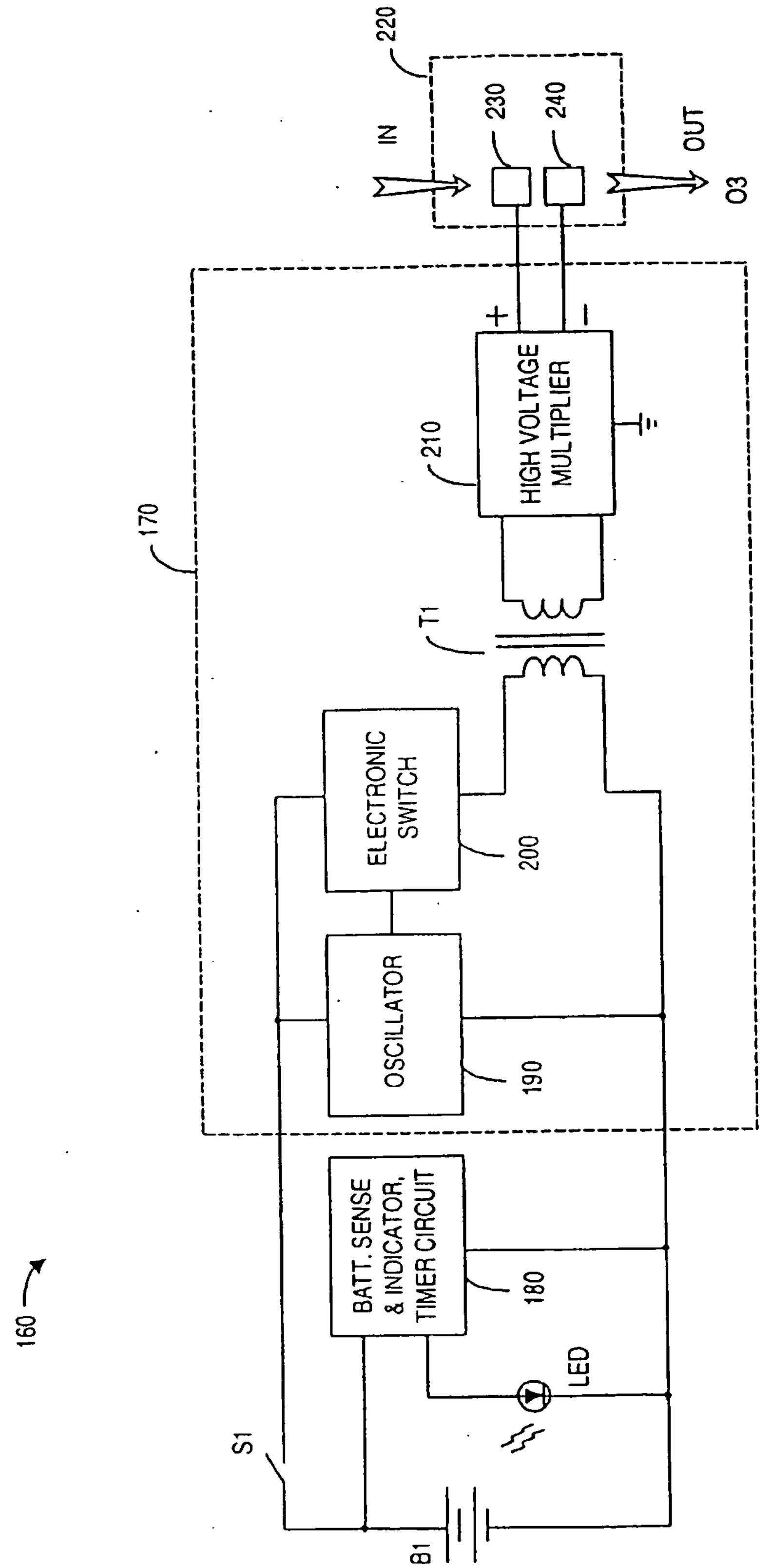
110
160
B_1
51
LED
130
100
IN
130
150
140
OUT
O_3
OUT
O_3
120

FIG. 2A



100
B_1
160
145
150
140
OUT
O_3
O_3
OUT
O_3
140
150
140

FIG. 2B



220
IN
230
240
OUT
O3
170
+
−
HIGH VOLTAGE
MULTIPLIER
210
T1
ELECTRONIC
SWITCH
200
OSCILLATOR
190
BATT. SENSE
& INDICATOR,
TIMER CIRCUIT
180
LED
S1
B1
160

FIG. 3

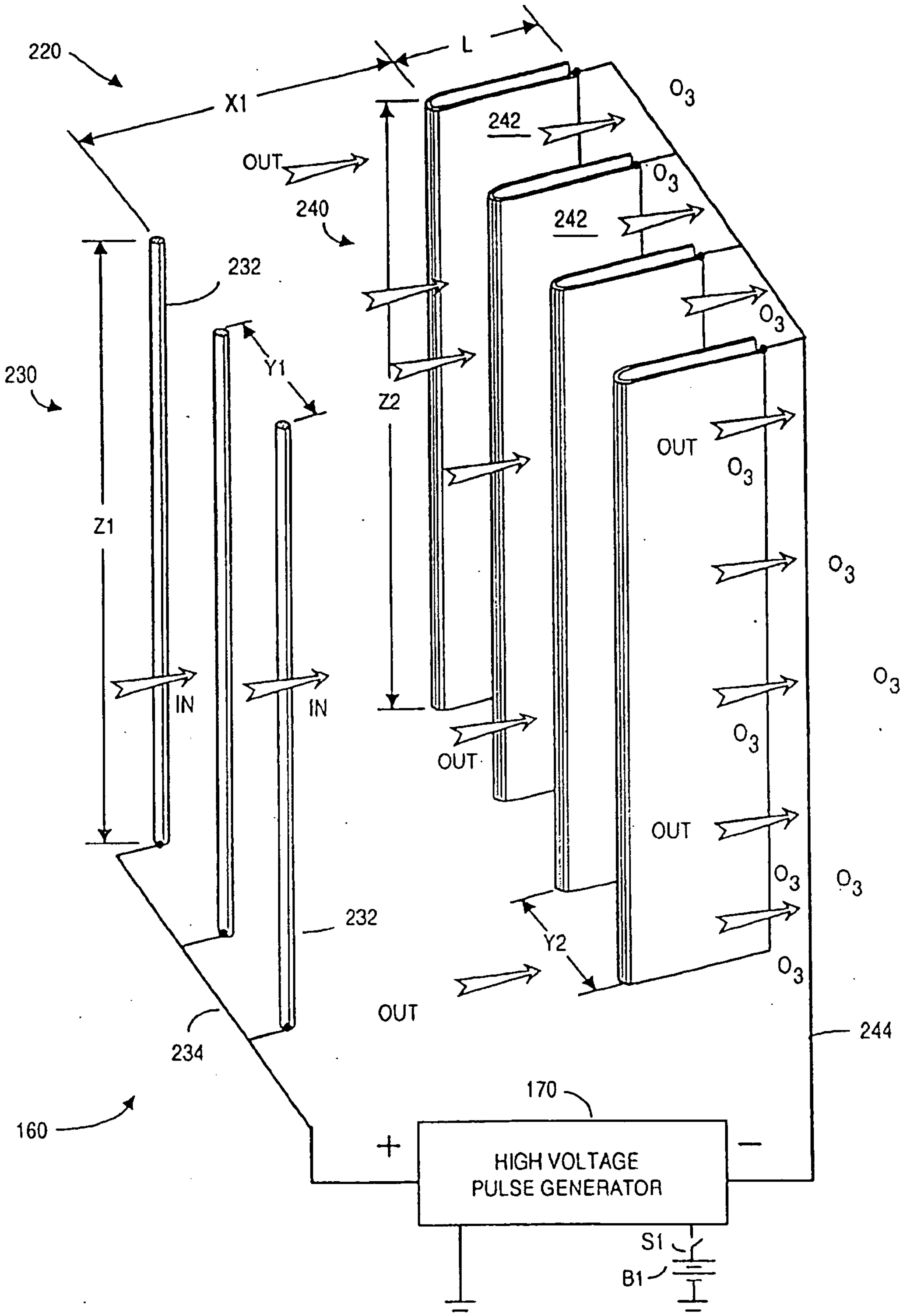

220
L
X1
O_3
242
OUT
240
242
232
230
Y1
Z2
Z1
IN
IN
OUT
O_3
OUT
232
Y2
OUT
234
244
160
170
+
−
HIGH VOLTAGE
PULSE GENERATOR
S1
B1

FIG. 4A

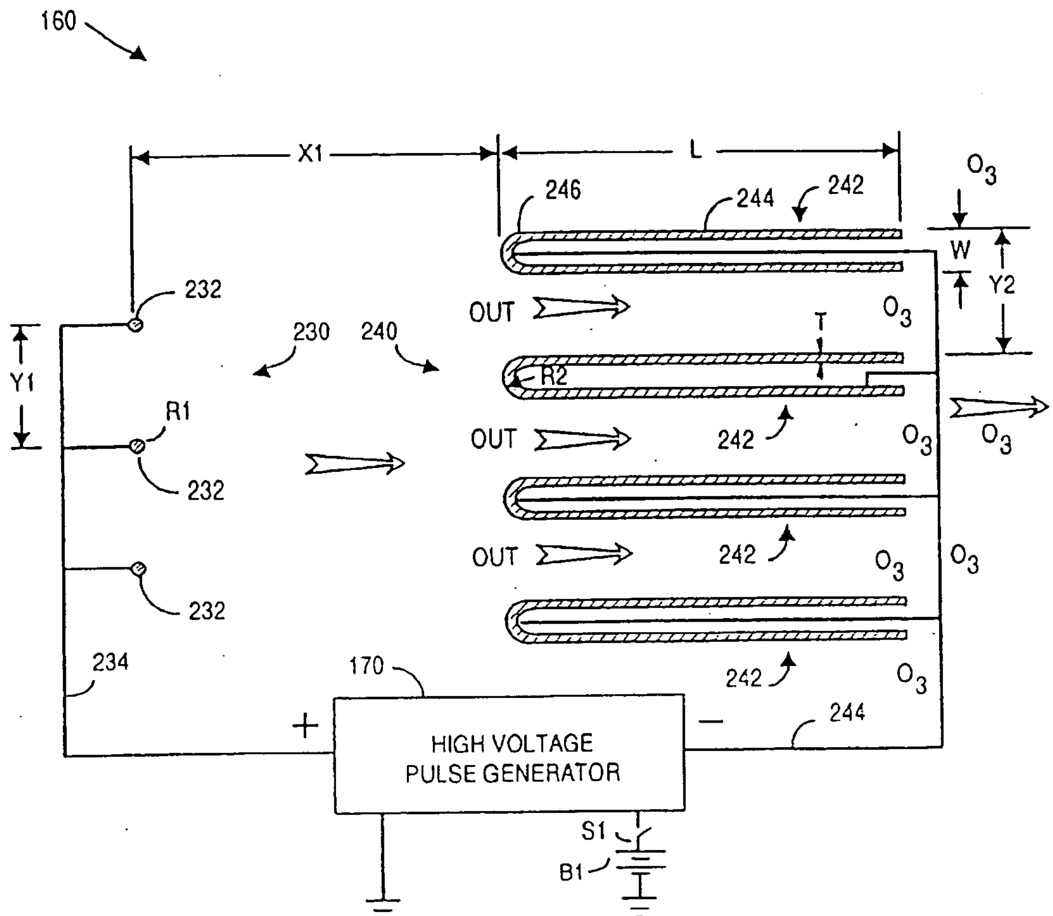
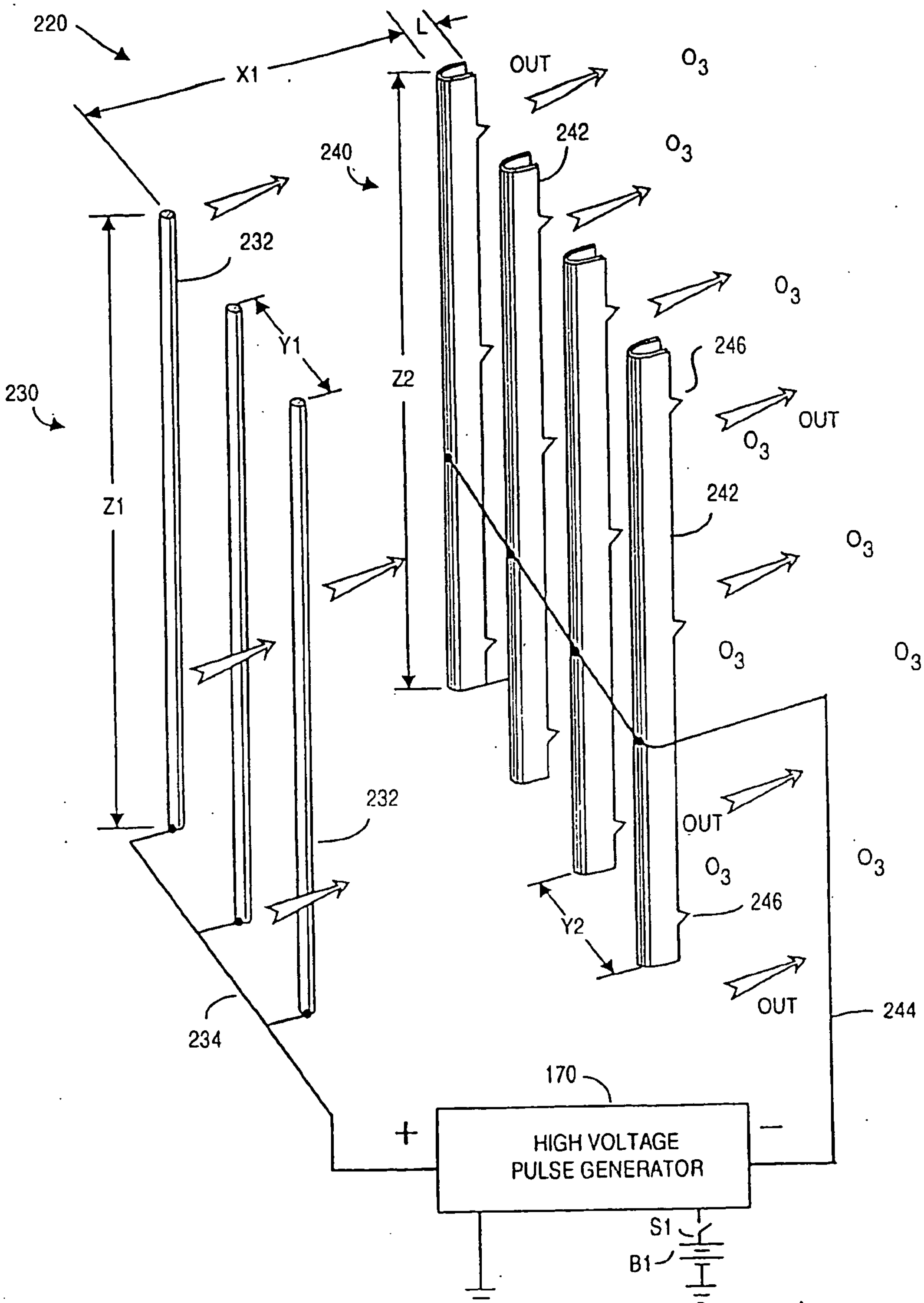

160
X1
L
246
244
242
O_3
W
Y2
232
230
240
OUT
T
R2
Y1
R1
232
242
232
234
170
244
HIGH VOLTAGE
PULSE GENERATOR
S1
B1

FIG. 4B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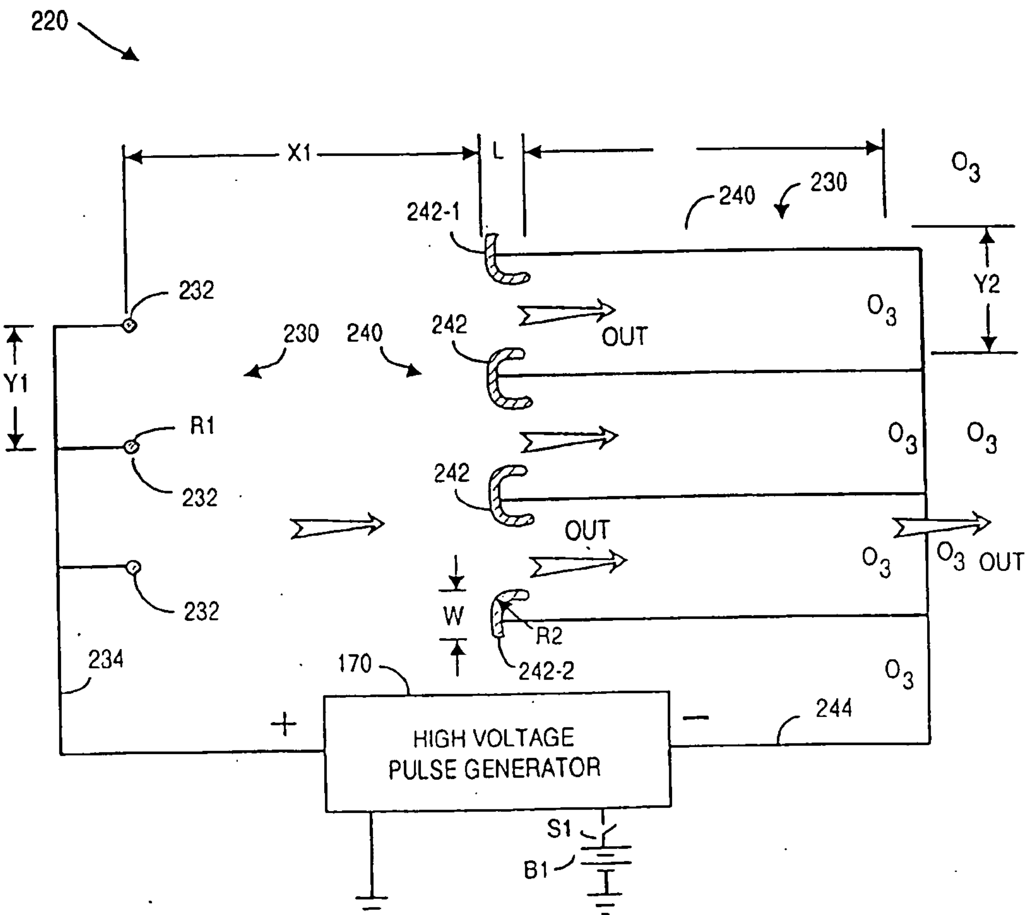
X1
L
OUT
O_3
240
242
232
Y1
Z2
246
230
Z1
232
OUT
242
Y2
OUT
234
244
170
+
HIGH VOLTAGE
PULSE GENERATOR
−
S1
B1

FIG. 4C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X1
L
O_3
240
230
242-1
Y2
232
O_3
230
240
242
OUT
Y1
R1
O_3
O_3
232
242
OUT
O_3
O_3 OUT
W
232
R2
234
170
242-2
O_3
244
+
−
HIGH VOLTAGE
PULSE GENERATOR
S1
B1

FIG. 4D

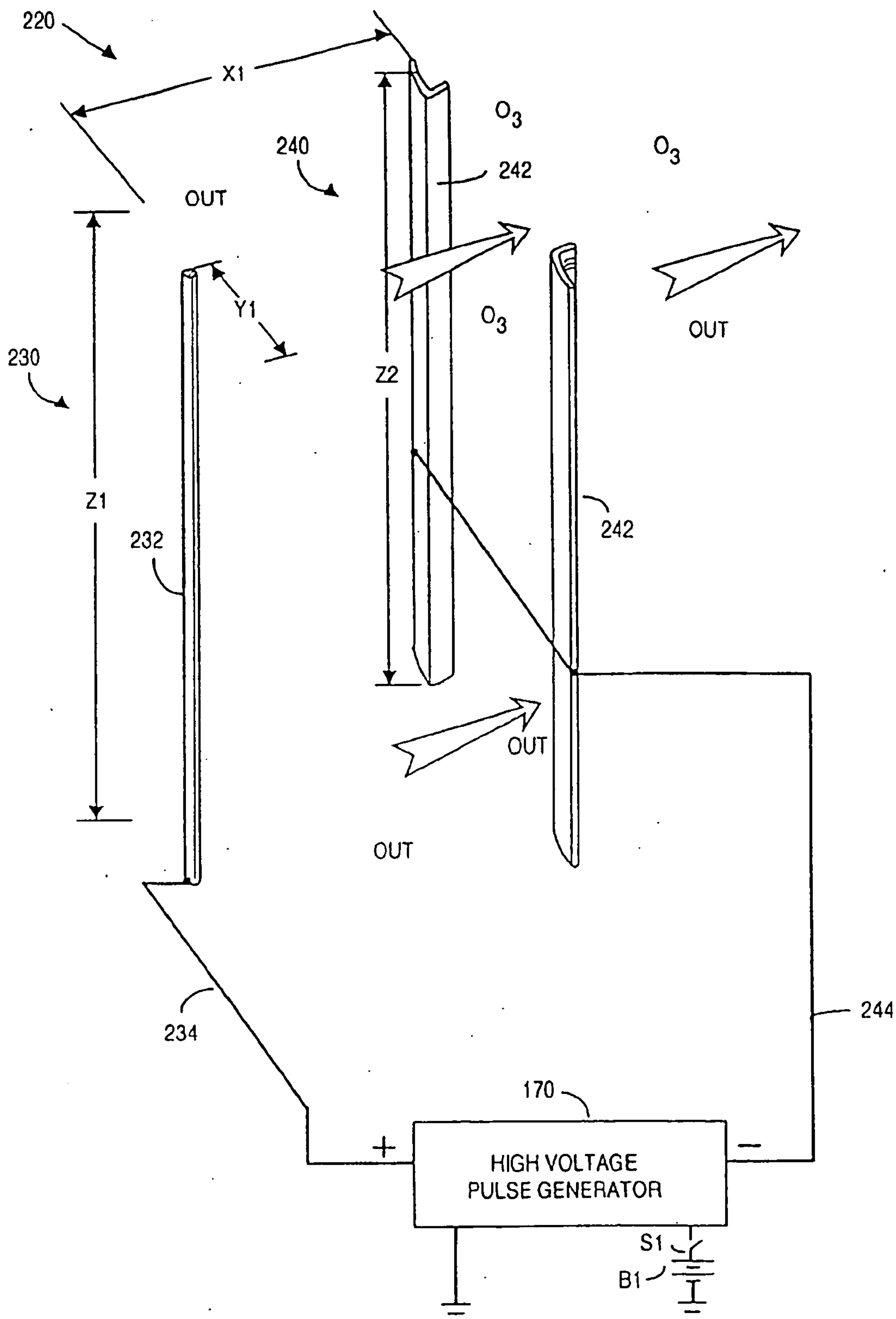
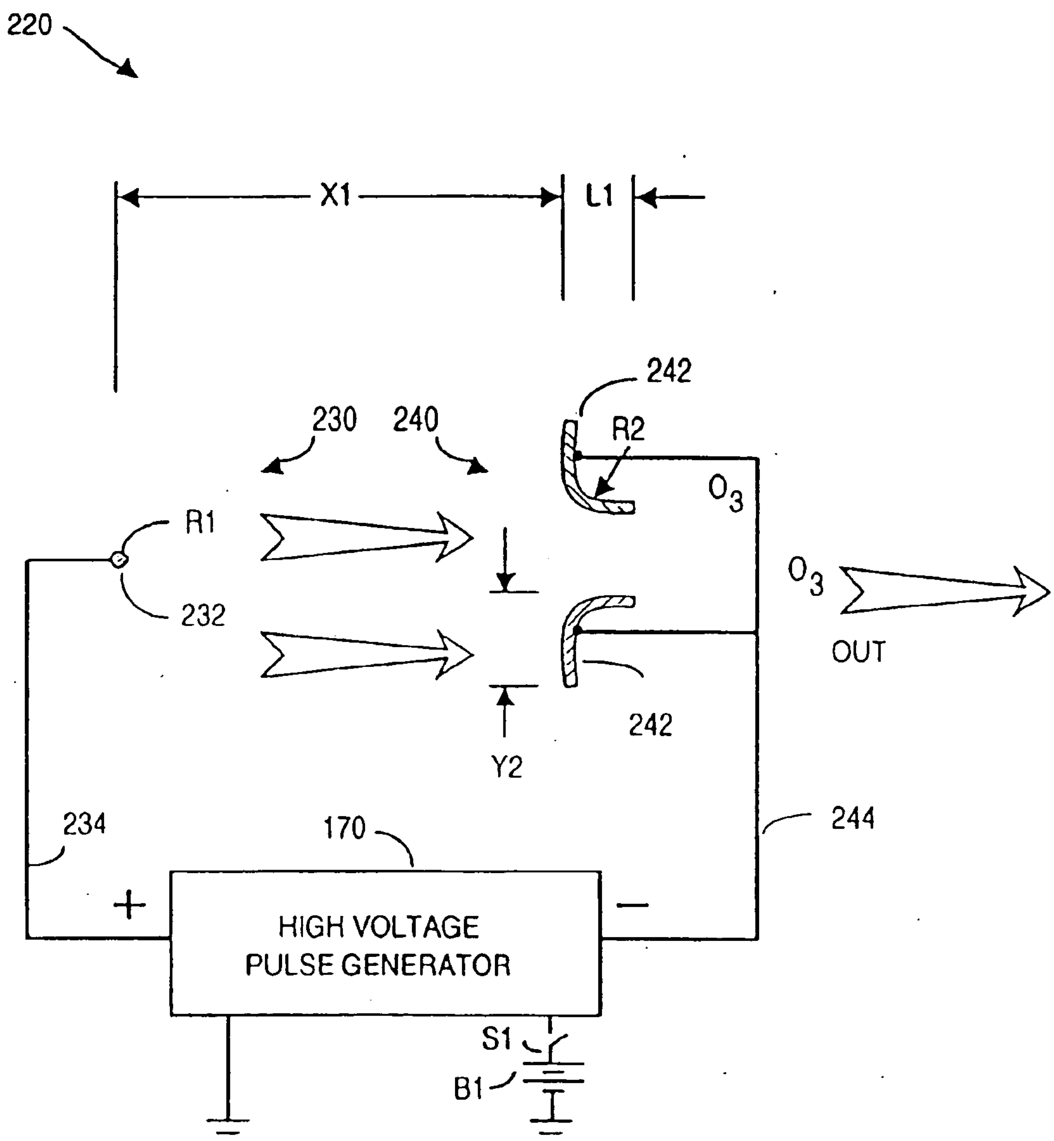

220
X1
240
242
O_3
O_3
OUT
Y1
230
O_3
OUT
Z2
Z1
232
242
OUT
OUT
234
244
170
+
−
HIGH VOLTAGE
PULSE GENERATOR
S1
B1

FIG. 4E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X1
L1
242
230
240
R2
O3
R1
O3
OUT
232
242
Y2
234
170
244
HIGH VOLTAGE
PULSE GENERATOR
S1
B1

FIG. 4F

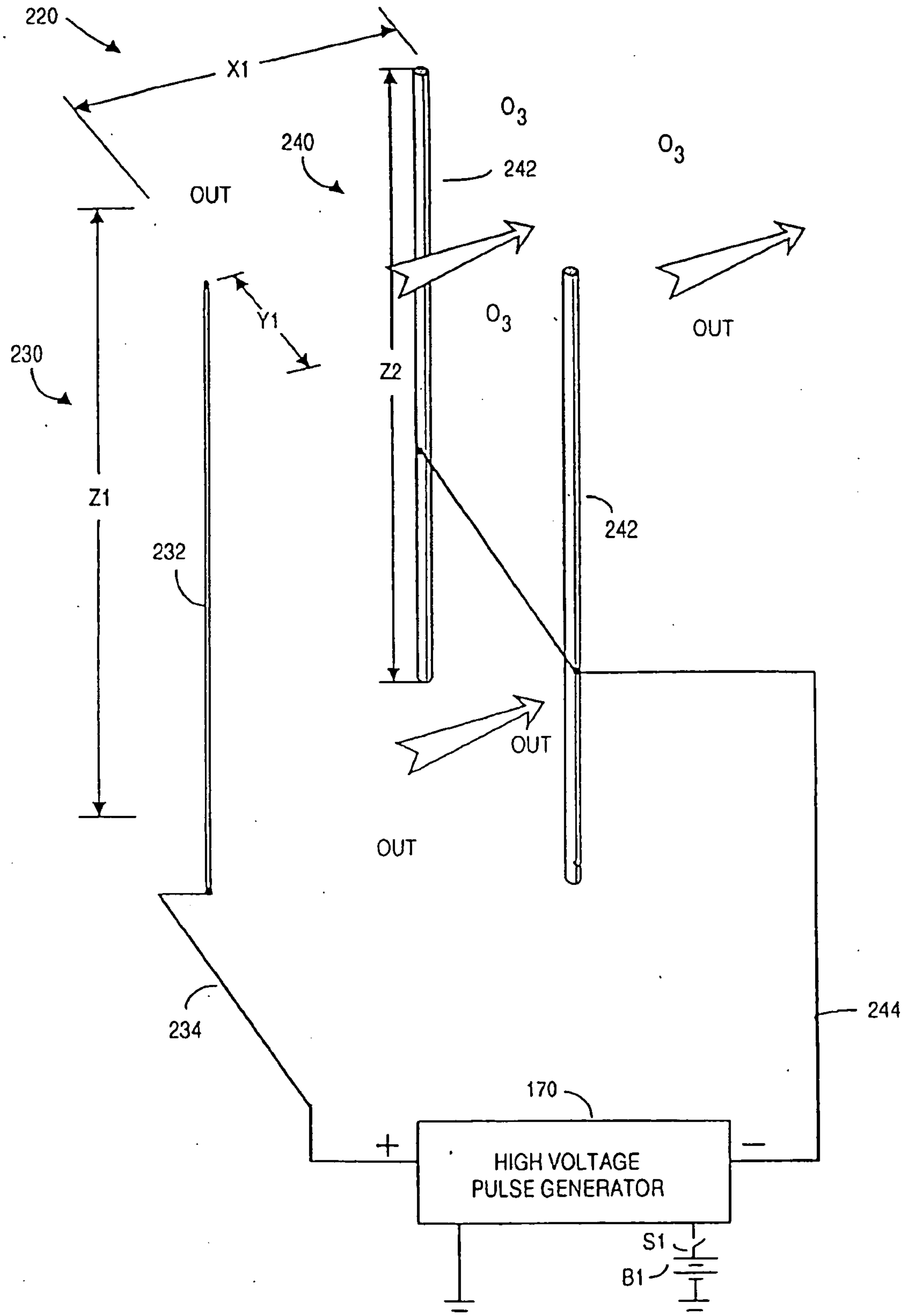
220
X1
240
242
O_3
O_3
OUT
230
Y1
Z2
O_3
OUT
Z1
232
242
OUT
OUT
234
244
170
+
HIGH VOLTAGE
PULSE GENERATOR
−
S1
B1

FIG. 4G

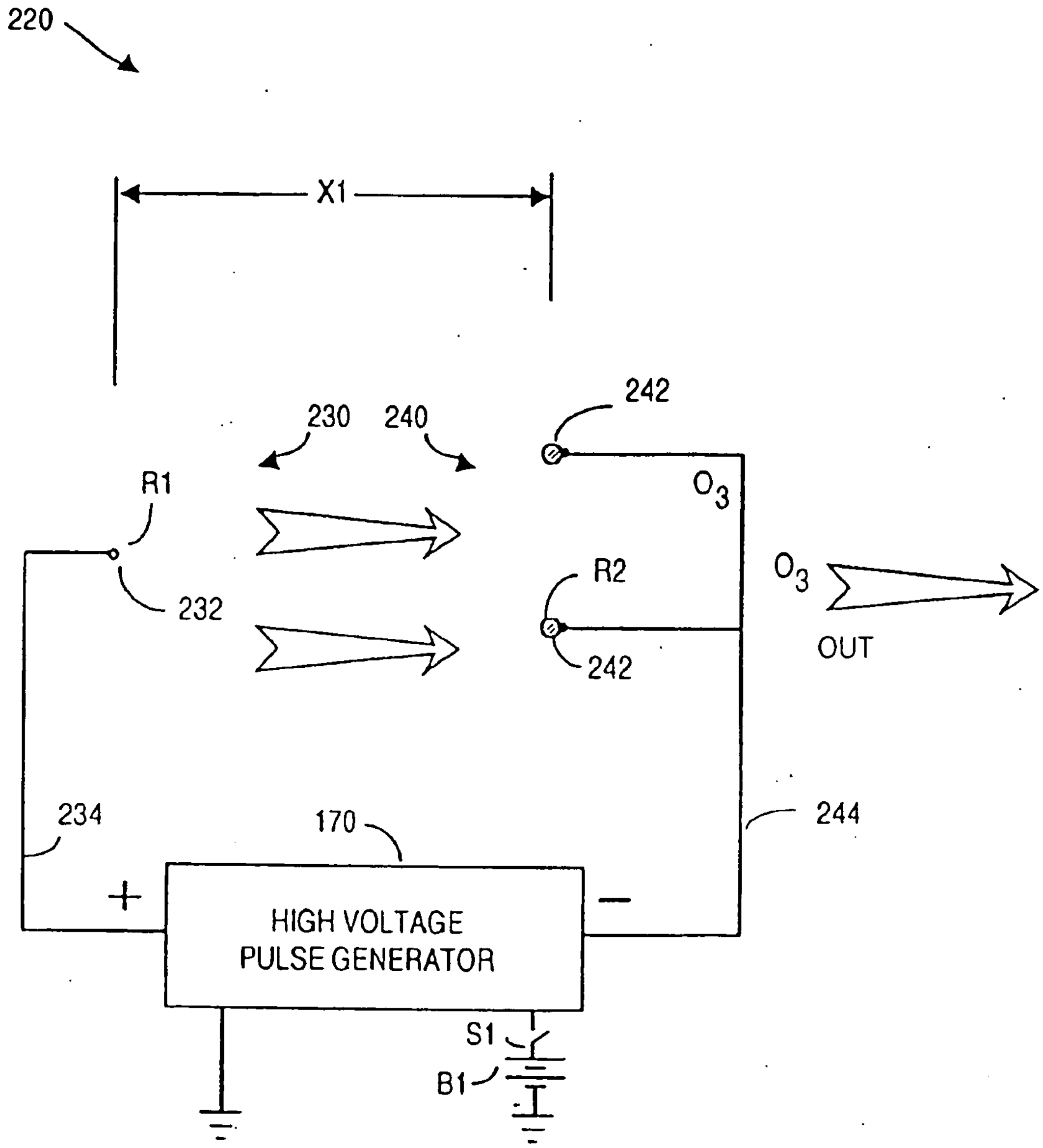
220
X1
230
240
242
R1
O_3
O_3
R2
232
OUT
242
234
170
244
HIGH VOLTAGE
PULSE GENERATOR
S1
B1

FIG. 4H

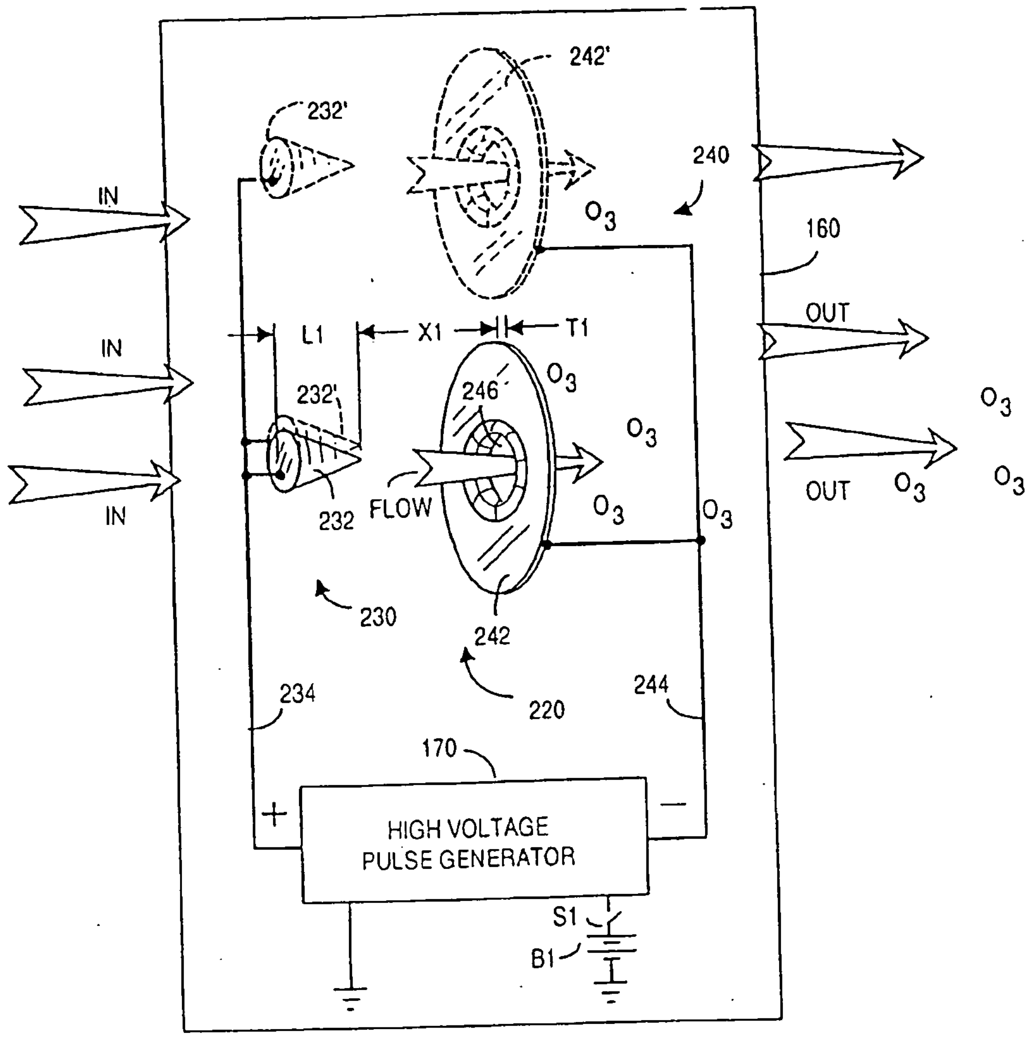

FIG. 4I

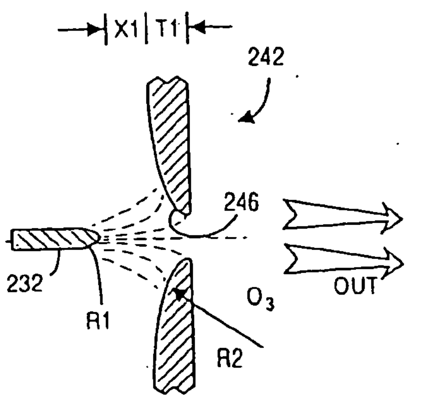

FIG. 4J

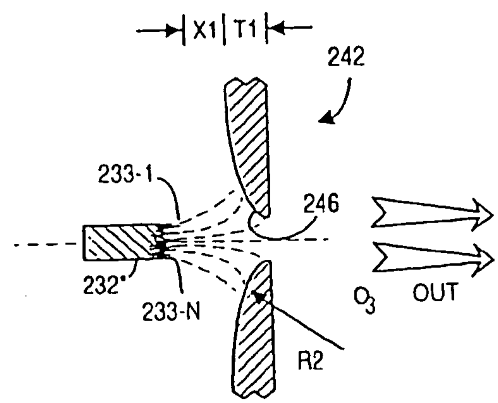

FIG. 4K

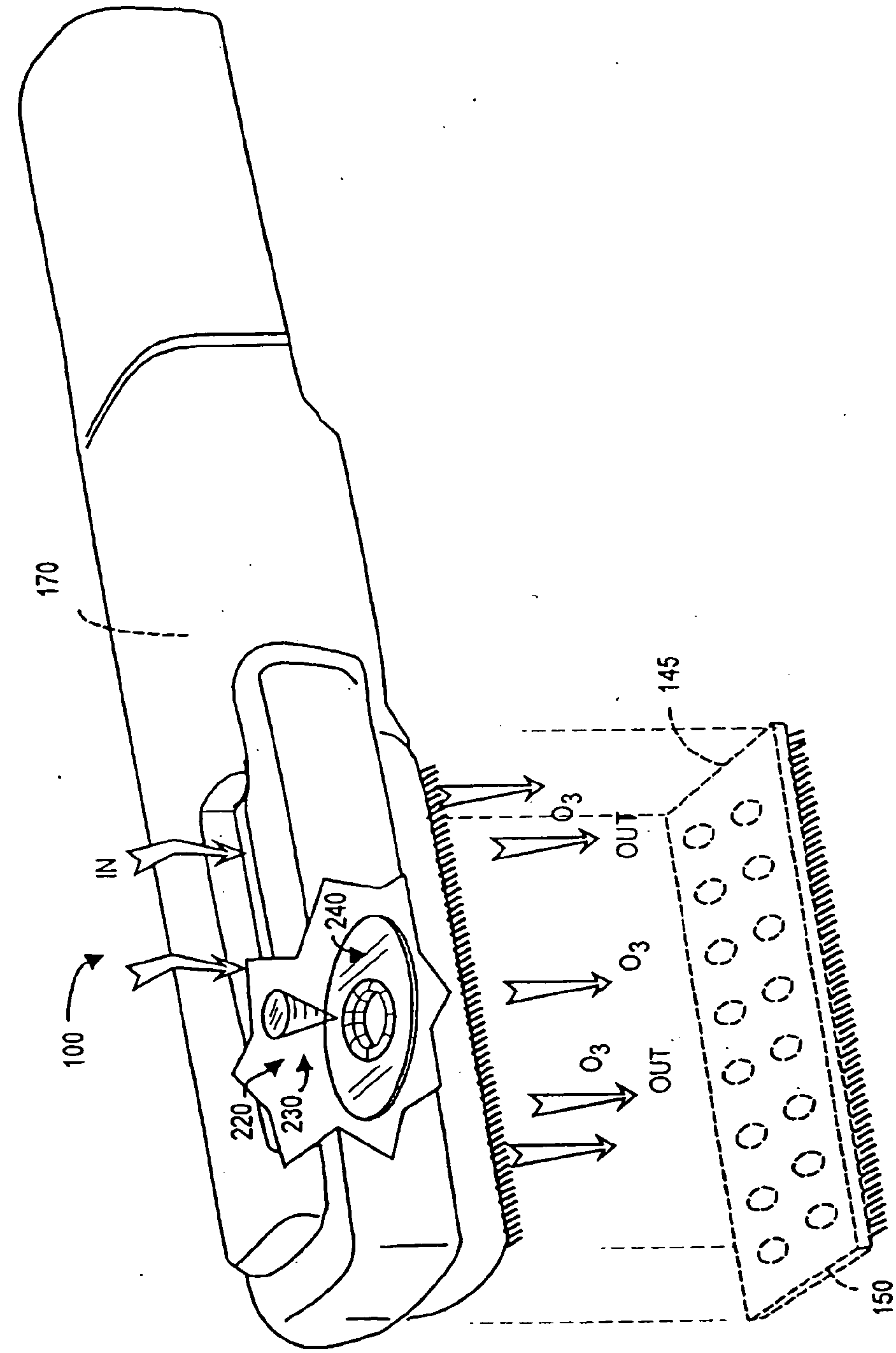

FIG. 5

ION EMITTING GROOMING BRUSH

CLAIM OF PRIORITY

This application is a continuation of U.S. patent application Ser. No. 09/742,814 filed Dec. 19, 2000 entitled "ION EMITTING GROOMING BRUSH" which is a continuation of U.S. patent application Ser. No. 09/415,576 filed Oct. 8, 1999 entitled "ION EMITTING GROOMING BRUSH", now U.S. Pat. No. 6,182,671 issued Feb. 6, 2001 which is a continuation of U.S. patent application Ser. No. 09/163,024 filed Sep. 29, 1998 entitled "ION EMITTING GROOMING BRUSH", now U.S. Pat. No. 5,975,090 issued Nov. 2, 1999, all of which applications are herein incorporated by reference.

FIELD OF THE INVENTION

This invention relates to grooming products and more specifically to brushes that remove hair, lint, etc. from clothing and promote grooming by emitting ionized air directed to the clothing being brushed.

BACKGROUND OF THE INVENTION

However common experience indicates that removing lint, hair, and the like from clothing by conventional brushing is not always successful. For example, static electricity may tend to bind hairs, lint, and other small debris to the surface of clothing. Although brushing one's clothing can mechanically remove some lint, hair, or other particles from the clothing surface, the brushing does not provide any conditioning of the clothing. Too often the lint and other material on the clothing is simply mechanically repositioned.

It is known in the art to produce an air flow electro-kinetically by directly converting electrical power into a flow of air without mechanically moving components. One such system is described in U.S. Pat. No. 4,789,801 to Lee (1988), depicted herein in simplified form as FIGS. 1A and 1B. Lee's system **10** provides a first array of small area ("minisectional") electrodes **20** is spaced-apart symmetrically from a second array of larger area ("maxisectional") electrodes **30**, with a high voltage (e.g., 5 KV) pulse generator **40** coupled between the two arrays. Generator **40** outputs high voltage pulses that ionize the air between the arrays, producing an air flow **50** from the minisectional array toward the maxisectional array results. The high voltage field present between the two arrays can release ozone (O_3), which can advantageously safely destroy many types of bacteria if excessive quantities of ozone are not released.

Unfortunately, Lee's tear-shaped maxisectional electrodes are relatively expensive to fabricate, most likely requiring mold-casting or extrusion processes. Further, air flow and ion generation efficiency is not especially high using Lee's configuration.

There is a need for a brush that can not only brush away lint, hair, etc. from clothing and other material, but provide a measure of cleaning and/or conditioning as well. Preferably such brush should subject the material being brushed to an ion flow to promote cleaning and grooming.

The present invention provides such a grooming brush.

SUMMARY OF THE PRESENT INVENTION

The present invention provides a brush whose body includes a handle portion and a head portion defining at least one vent and including projecting bristles. More preferably, the head portion upperside will define at least one air intake

vent and the head portion underside defines at least one ionized air outlet vent.

Contained within the brush body is a battery-operated ionizer unit with DC battery power supply. The ionizer unit includes a DC:DC inverter that boosts the battery voltage to high voltage, and a pulse generator that receives the high voltage DC and outputs high voltage pulses of perhaps 10 KV peak-to-peak, although high voltage DC could be used instead of pulses. The unit also includes an electrode assembly unit comprising first and second spaced-apart arrays of conducting electrodes, the first array and second array being coupled, respectively, preferably to the positive and negative output ports of the high voltage pulse generator.

The electrode assembly preferably is formed using first and second arrays of readily manufacturable electrode types. In one embodiment, the first array comprises wire-like electrodes and the second array comprises "U"-shaped electrodes having one or two trailing surfaces. In an even more efficient embodiment, the first array includes at least one pin or cone-like electrode and the second array is an annular washer-like electrode. The electrode assembly may comprise various combinations of the described first and second array electrodes. In the various embodiments, the ratio between effective area of the second array electrodes to the first array electrodes is at least about 20:1.

The high voltage pulses create an electric field between the first and second electrode arrays. This field produces an electro-kinetic airflow going from the first array toward the second array, the airflow being rich in ions and in ozone (O_3). Ambient air enters the brush head via air intake vent(s), and ionized air (with ozone) exits the brush through outlet vent(s) in the bristle portion of the head. However, in practice if only one vent is present, it suffices as both an intake and an outlet vent. Preferably a visual indicator is coupled to the ionizer unit to visually confirm to a user when the unit is ready for ionizing operation, and when ionization is actually occurring.

Clothing or other material brushed with the bristles is subjected to a gentle flow of ionized air from the outlet vent(s). The brushed material soon takes on a more conditioned appearance, compared to material groomed with an ordinary lint-type brush. The ozone emissions can kill many types of germs and bacteria that may be present on the clothing and can deodorize the clothing surface.

Other features and advantages of the invention will appear from the following description in which the preferred embodiments have been set forth in detail, in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A and 1B are depictions of Lee-type electrostatic generators, according to the prior art;

FIG. 2A is an perspective view of a preferred embodiment of an ionizing brush, according to the present invention;

FIG. 2B is a bottom view of a preferred embodiment of an ionizing brush, according to the present invention;

FIG. 3 is an electrical block diagram of the present invention;

FIG. 4A is a perspective block diagram showing a first embodiment for an electrode assembly, according to the present invention;

FIG. 4B is a plan block diagram of the embodiment of FIG. 4A;

FIG. 4C is a perspective block diagram showing a second embodiment for an electrode assembly, according to the present invention;

FIG. 4D is a plan block diagram of a modified version of the embodiment of FIG. 4C;

FIG. 4E is a perspective block diagram showing a third embodiment for an electrode assembly, according to the present invention;

FIG. 4F is a plan block diagram of the embodiment of FIG. 4E;

FIG. 4G is a perspective block diagram showing a fourth embodiment for an electrode assembly, according to the present invention;

FIG. 4H is a plan block diagram of the embodiment of FIG. 4G;

FIG. 4I is a perspective block diagram showing a fifth embodiment for an electrode assembly, according to the present invention;

FIG. 4J is a detailed cross-sectional view of a portion of the embodiment of FIG. 4I;

FIG. 4K is a detailed cross-sectional view of a portion of an alternative to the embodiment of FIG. 4I;

FIG. 5 is a cutaway perspective view of the present invention showing location of the electrode assembly, according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIGS. 2A and 2B depict an ionized brush **100** according to the present invention as having a body that includes a handle portion **110** and a head portion **120**. Head portion **120** includes one or more air intake vents **130**, brush bristles **140** that protrude from a brush plate **145** attached to the brushing surface of the brush, and one or more outlet vents **150**.

Brush **100** is similar to what was described in FIGS. **2A** and **2B** in the parent application, except that for a brush to remove lint, hair, etc., bristles **140** will typically be shorter and may be biased at a common angle and formed on a cloth substrate. However whether brush plate **145** includes long bristles or short bristles is unimportant to operation of the present invention.

Internal to the brush body is anion generating unit **160**, powered by a battery **B1** (preferably at least 6 VDC) contained within the brush and energizable via a switch **S1**, preferably mounted on the brush **100**. As such, ion generating unit **160** is self-contained in that other than ambient air, nothing is required from beyond the body of the brush for operation of the present invention. Of course if desired, a DC power supply could be disposed external to the brush body, and power brought into the hair brush via a cable.

Preferably handle portion **110** is detachable from head portion **120**, to provide access to battery **B1**, preferably five NiCd rechargeable cells or four disposable cells. The housing material is preferably inexpensive, lightweight, and easy to fabricate, ABS plastic for example. Brush **100** is preferably approximately the size of typical brushes, for example an overall length of perhaps 235 mm, and a maximum width of perhaps 58 mm, although other dimensions can of course be used.

Brush plate **145** maybe removably attached to hairbrush **100**, for ease of cleaning the bristles, for providing access to an ion-emitting electrode assembly within the brush head, as well as for inserting a different brush plate bearing a different type of bristles. Different types or shapes or configurations of bristles might be used interchangeably simply by inserting different brush plate-bristle assemblies into the head portion of the present invention.

It will also be appreciated that use of the present invention is not limited to a single grooming function. Thus, whereas bristles **140** might be fabricated from nylon or plastic for one grooming application, the bristles might instead be metal for use in another application. Thus, if desired, a brush plate **145** containing nylon bristles could be replaced with a different brush plate containing metal bristles.

The ability to remove brush plate **145** also provides ready access to electrodes within the brush head, for purposes of cleaning and, if necessary, replacement. It is to be understood that although FIGS. **2A** and **2B** depict an exemplary embodiment for brush **100**, other configurations maybe used. Different configurations of inlet vent(s) **130** and/or outlet vent(s) **150** maybe used. Thus, more or fewer such vents may be provided, the locations location and/or shapes of which may differ from what is depicted in FIGS. **2A** and **2B**. The purpose of vents **130** and **150** is to ensure that an adequate flow of ambient air maybe drawn into or made available to unit **130**, and that an adequate flow of ionized air that includes safe amounts of O_3 flows out from unit **130** towards the grooming area.

As best seen in FIG. **3**, ion generating unit **160** includes a high voltage pulse generator unit **170** and optionally an indicator circuit **180**. Circuit **180** senses potential on battery **B1** and indicates whether battery potential is sufficient to generate ions and when ion generation is occurring. In the preferred embodiment, a visual indicator is used, preferably a two-color light emitting diode ("LED"). Of course other indicator devices maybe used, including for example, blinking indicator(s), and/or audible indicator(s). Optionally, circuit **180** includes timing components that will turn-off generation of ions and ozone after a predetermined time, for example two minutes. Such a turn-off feature will preserve battery lifetime in the event **S1** is other than a push-to-maintain contact type switch. Thus, a user who pushes **S1** and uses the brush but forgets to turn-off **S1** will not necessarily deplete battery **B1**, as circuitry **180** will turn-off the present invention for the user.

As shown in FIG. **3**, high voltage pulse generator unit **170** preferably comprises a low voltage oscillator circuit **190** of perhaps 20 KHz frequency, that outputs low voltage pulses to an electronic switch **200**, e.g., a thyristor or the like. Switch **200** switchably couples the low voltage pulses to the input winding of a step-up transformer **T1**. The secondary winding of **T1** is coupled to a high voltage multiplier circuit **210** that outputs high voltage pulses. Preferably the circuitry and components comprising high voltage pulse generator **170** and sense/indicator circuit (and timing circuit) **180** are fabricated on a printed circuit board that is mounted within head portion **120** of hair brush **100**.

Output pulses from high voltage generator **170** preferably are at least 10 KV peak-to-peak with an effective DC offset of perhaps half the peak-to-peak voltage, and have a frequency of perhaps 20 KHz. The pulse train output preferably has a duty cycle of perhaps 10%, which will promote battery lifetime. Of course, different peak-peak amplitudes, DC offsets, pulse train wave shapes, duty cycle, and/or repetition frequencies may instead be used. Indeed, a 100% pulse train (e.g., an essentially DC high voltage) maybe used, albeit with shorter battery lifetime.

Frequency of oscillation is not especially critical but frequency of at least about 20 KHz is preferred as being inaudible to humans. However if brush **100** is intended for use in the immediate vicinity of pets, even higher operating frequency maybe desired such that the present invention does not emit audible sounds that would disturb nearby animals.

The output from high voltage pulse generator unit **170** is coupled to an electrode assembly **220** that comprises a first

electrode array 230 and a second electrode array 240. Unit 170 functions as a DC:DC high voltage generator, and could be implemented using other circuitry and/or techniques to output high voltage pulses that are input to electrode assembly 220.

In the embodiment of FIG. 3, the positive output terminal of unit 170 is coupled to first electrode array 230, and the negative output terminal is coupled to second electrode array 240. This coupling polarity has been found to work well. An electrostatic flow of air is created, going from the first electrode array towards the second electrode array. (This flow is denoted "OUT" in the figures.) Accordingly electrode assembly 220 is mounted in the head portion 120 of brush 100 such that second electrode array 240 is closer to the brushing surface (e.g., bristle-containing region where outlet vent(s) 150 are located) than is first electrode array 230.

When voltage or pulses from high voltage pulse generator 170 are coupled across first and second electrode arrays 230 and 240, it is believed that a plasma-like field is created surrounding electrodes 232 in first array 230. This electric field ionizes the air between the first and second electrode arrays and establishes an "OUT" airflow that moves towards the second array. It is understood that the IN flow enters brush 100 via vent(s) 130, and that the OUT flow exits brush 100 via vent(s) 150.

It is believed that ozone and ions are generated simultaneously by the first array electrode(s) 232, essentially as a function of the potential from generator 170 coupled to the first array. Ozone generation maybe increased or decreased by increasing or decreasing the potential at the first array. Coupling an opposite polarity potential to the second array electrode(s) 242 essentially accelerates the motion of ions generated at the first array, producing the air flow denoted as "OUT" in the figures. As the ions move toward the second array, it is believed that they push or move air molecules toward the second array. The relative velocity of this motion may be increased by decreasing the potential at the second array relative to the potential at the first array.

For example, if +10 KV were applied to the first array electrode(s), and no potential were applied to the second array electrode(s), a cloud of ions (whose net charge is positive) would form adjacent the first electrode array. Further, the relatively high 10 KV potential would generate substantial ozone. By coupling a relatively negative potential to the second array electrode(s), the velocity of the air mass moved by the net emitted ions increases, as momentum of the moving ions is conserved.

On the other hand, if it were desired to maintain the same effective outflow (OUT) velocity but to generate less ozone, the exemplary 10 KV potential could be divided between the electrode arrays. For example, generator 170 could provide +6 KV (or some other fraction) to the first array electrode(s) and −4 KV (or some other fraction) to the second array electrode(s). In this example, it is understood that the +6 KV and the −4 KV are measured relative to ground. Understandable it is desired that the present invention operate to output safe amounts of ozone.

As noted, outflow (OUT) preferably includes safe amounts of O_3 that can destroy or at least substantially alter bacteria, germs, and other living (or quasi-living) matter subjected to the outflow. Thus, when switch S1 is closed and B1 has sufficient operating potential, pulses from high voltage pulse generator unit 170 create an outflow (OUT) of ionized air and O_3. When S1 is closed, LED will first visually signal whether sufficient B1 potential is present, and

if present, then signal when ionization is occurring. If LED fails to indicate sufficient operating voltage, the user will know to replace B1 or, if rechargeable cells are used, to recharge B1. For example, if visual indicator is a two-color device, the LED could signal red when B1 potential exceeds a minimum threshold, e.g., 5.5 VDC. Further, LED could then signal green when S1 is depressed and unit 160 is actually outputting ionized air. If the battery potential is too low, the LED will not light, which advises the user to replace or re-charge battery source B1.

Preferably operating parameters of the present invention are set during manufacture and are not user-adjustable. For example, increasing the peak-to-peak output voltage and/or duty cycle in the high voltage pulses generated by unit 170 can increase air flowrate, ion content, and ozone content. In the preferred embodiment, output flowrate is about 90 feet/minute, ion content is about 2,000,000/cc and ozone content is about 50 ppb (over ambient) to perhaps 2,000 ppb (over ambient). Decreasing the R2/R1 ratio below about 20:1 will decrease flow rate, as will decreasing the peak-to-peak voltage and/or duty cycle of the high voltage pulses coupled between the first and second electrode arrays.

In practice, a user holds and uses brush 100 in conventional fashion to brush clothing or other material. With S1 energized, ionization unit 160 emits ionized air and preferably some ozone (O_3) via outlet vents 150. The material being groomed advantageously is subjected to this outflow ("OUT") of air and ozone. Beneficially, the brushed material seems to align together more coherently than when using a non-ionized brush.

Odors in the material being brushed will diminish, and some types of germs or bacteria, if present, can be killed by the outflow from brush 100. In short, not only is the material brushed and groomed more effectively than with a passive prior art brush, e.g., a brush that does not actively emit ions, but hygiene is promoted as well.

Having described various aspects of the invention in general, preferred embodiments of electrode assembly 220 will now be described in the various embodiments, electrode assembly 220 will comprise a first array 230 of at least one electrode 232, and will further comprise a second array 240 of preferably at least one electrode 242. Understandably material(s) for electrodes 232 and 242 should conduct electricity, be resilient to corrosive effects from the application of high voltage, yet be strong enough to be cleaned.

In the various electrode assemblies to be described herein, electrode(s) 232 in the first electrode array 230 are preferably fabricated from tungsten. Tungsten is sufficiently robust to withstand cleaning, has a high melting point to retard breakdown due to ionization, and has a rough exterior surface that seems to promote efficient ionization. On the other hand, electrodes 242 preferably will have a highly polished exterior surface to minimize unwanted point-to-point radiation. As such, electrodes 242 preferably are fabricated from stainless steel, brass, among other materials. The polished surface of electrodes 232 also promotes ease of electrode cleaning.

In contrast to the prior art electrodes disclosed by Lee, electrodes 232 and 242 according to the present invention are light weight, easy to fabricate, and lend themselves to mass production. Further, electrodes 232 and 242 described herein promote more efficient generation of ionized air, and production of safe amounts of ozone, O_3.

In the present invention, a high voltage pulse generator 170 is coupled between the first electrode array 230 and the second electrode array 240. The high voltage pulses produce

a flow of ionized air that travels in the direction from the first array towards the second array (indicated herein by hollow arrows denoted "OUT"). As such, electrode(s) 232 may be referred to as an emitting electrode, and electrodes 242 maybe referred to as collector electrodes. This outflow advantageously contains safe amounts of O_3, and exits the present invention from vent(s) 150, as shown in FIGS. 2A and 2B. Although a generator of high voltage pulses is preferred and will promote battery life, in practice high voltage DC (e.g., pulses having 100% duty cycle) may instead be used.

According to the present invention, it is preferred that the positive output terminal or port of the high voltage pulse generator be coupled to electrodes 232, and that the negative output terminal or port be coupled to electrodes 242. It is believed that the net polarity of the emitted ions is positive, e.g., more positive ions than negative ions are emitted. In any event, the preferred electrode assembly electrical coupling minimizes audible hum from electrodes 232 contrasted with reverse polarity (e.g., interchanging the positive and negative output port connections). Further, the preferred electrical coupling seems to produce ions that help keep hair in place, as opposed to putting a static charge into the hair that can produce an undesired "fly-away" hair appearance. In some embodiments, however, one port (preferably the negative port) of high voltage pulse generator may in fact be the ambient air. Thus, electrodes in the second array need not be connected to the high voltage pulse generator using wire. Nonetheless, there will be an "effective connection" between the second array electrodes and one output port of the high voltage pulse generator, in this instance, via ambient air.

Turning now to the embodiments of FIGS. 4A and 4B, electrode assembly 220 comprises a first array 230 of wire electrodes 232, and a second array 240 of generally "U"-shaped electrodes 242. In preferred embodiments, the number N1 of electrodes comprising the first array will differ by one relative to the number N2 of electrodes comprising the second array. In many of the embodiments shown, N2>N1. However, if desired, in FIG. 4A, addition first electrodes 232 could be added at the out ends of array 230 such that N1>N2, e.g., five electrodes 232 compared to four electrodes 242.

Electrodes 232 are preferably lengths of tungsten wire, whereas electrodes 242 are formed from sheet metal, preferably stainless steel, although brass or other sheet metal could be used. The sheet metal is readily formed to define side regions 244 and bulbous nose region 246 for hollow elongated "U" shaped electrodes 242. While FIG. 4A depicts four electrodes 242 in second array 240 and three electrodes 232 in first array 230, as noted, other numbers of electrodes in each array could be used, preferably retaining a symmetrically staggered configuration as shown.

As best seen in FIG. 4B, the spaced-apart configuration between the arrays is staggered such that each first array electrode 232 is substantially equidistant from two second array electrodes 242. This symmetrical staggering has been found to be an especially efficient electrode placement. Preferably the staggering geometry is symmetrical in that adjacent electrodes 232 or adjacent electrodes 242 are spaced-apart a constant distance, Y1 and Y2 respectively. However, a non-symmetrical configuration could also be used, although ion emission and air flow would likely be diminished. Also, it is understood that the number of electrodes 232 and 242 may differ from what is shown.

In FIGS. 4A, typically dimensions are as follows: diameter of electrodes 232 is about 0.08 mm, distances Y1 and Y2 are each about 16 mm, distance X1 is about 16 mm, distance L is about 20 mm, and electrode heights Z1 and Z2 are each about 100 mm. The width W of electrodes 242 is preferably about 4 mm, and the thickness of the material from which electrodes 242 are formed is about 0.5 mm. Of course other dimensions and shapes could be used. It is preferred that electrodes 232 be small in diameter to help establish a desired high voltage field. On the other hand, it is desired that electrodes 232 (as well as electrodes 242) be sufficiently robust to withstand occasional cleaning.

Electrodes 232 in first array 230 are coupled by a conductor 234 to a first (preferably positive) output port of high voltage pulse generator 170, and electrodes 242 in second array 240 are coupled by a conductor 244 to a second (preferably negative) output port of generator 170. It is relatively unimportant where on the various electrodes electrical connection is made to conductors 234 or 244. Thus, by way of example FIG. 4B depicts conductor 244 making connection with some electrodes 242 internal to bulbous end 246, while other electrodes 242 make electrical connection to conductor 244 elsewhere on the electrode. Electrical connection to the various electrodes 242 could also be made on the electrode external surface providing no substantial impairment of the outflow air stream results.

The ratio of the effective electric field emanating area of electrode 232 to the nearest effective area of electrodes 242 is at least about 15:1, and preferably is at least 20:1. Beyond a ratio of say 35:1, little or no performance improvement results. Thus, in the embodiment of FIG. 4A and FIG. 4B, the ratio R2/R1≈2 mm/0.08 mm≈25:1.

In this and the other embodiments to be described herein, ionization appears to occur at the smaller electrode(s) 232 in the first electrode array 230, with ozone production occurring as a function of high voltage arcing. For example, increasing the peak-to-peak voltage amplitude and/or duty cycle of the pulses from the high voltage pulse generator 170 can increase ozone content in the output flow of ionized air.

In the embodiment of FIGS. 4A and 4C, each "U"-shaped electrode 242 has two trailing edges 244 that promote efficient kinetic transport of the outflow of ionized air and O_3. By contrast, the embodiments of FIGS. 4C and 4D depict somewhat truncated versions of electrodes 242. Whereas dimension L in the embodiment of FIGS. 4A and 4B was about 20 mm, in FIGS. 4C and 4D, L has been shortened to about 8 mm. Other dimensions in FIG. 4C preferably are similar to those stated for FIGS. 4A and 4B. In FIGS. 4C and 4D, the inclusion of point-like regions 246 on the trailing edge of electrodes 242 seems to promote more efficient generation of ionized air flow. It will be appreciated that the configuration of second electrode array 240 in FIG. 4C can be more robust than the configuration of FIGS. 4A and 4B, by virtue of the shorter trailing edge geometry. As noted earlier, a symmetrical staggered geometry for the first and second electrode arrays is preferred for the configuration of FIG. 4C.

In the embodiment of FIG. 4D, the outermost second electrodes, denoted 242-1 and 242-2, have substantially no outermost trailing edges. Dimension L in FIG. 4D is preferably about 3 mm, and other dimensions maybe as stated for the configuration of FIGS. 4A and 4B. Again, the R2/R1 ratio for the embodiment of FIG. 4D preferably exceeds about 20:1.

FIGS. 4E and 4F depict another embodiment of electrode assembly 220, in which the first electrode array comprises a single wire electrode 232, and the second electrode array comprises a single pair of curved "L"-shaped electrodes 242,

in cross-section. Typical dimensions, where different than what has been stated for earlier-described embodiments, are X1≈12 mm, Y1≈6 mm, Y2≈3 mm, and L1≈3 mm. The effective R2/R1 ratio is again greater than about 20:1. The fewer electrodes comprising assembly **220** in FIGS. **4E** and **4F** promote economy of construction, and ease of cleaning, although more than one electrode **232**, and more than two electrodes **242** could of course be employed. This embodiment again incorporates the staggered symmetry described earlier, in which electrode **232** is equidistant from two electrodes **242**.

FIGS. **4G** and **4H** shown yet another embodiment for electrode assembly **220**. In this embodiment, first electrode array **230** is a length of wire **232**, while the second electrode array **240** comprises a pair of rod or columnar electrodes **242**. As in embodiments described earlier herein, it is preferred that electrode **232** be symmetrically equidistant from electrodes **242**. Wire electrode **232** is preferably perhaps 0.08 mm tungsten, whereas columnar electrodes **242** are perhaps 2 mm diameter stainless steel. Thus, in this embodiment the R2/R1 ratio is about 25:1. Other dimensions may be similar to other configurations, e.g., FIGS. **4E**, **4F**. Of course electrode assembly **220** may comprise more than one electrode **232**, and more than two electrodes **242**.

An especially preferred embodiment is shown in FIG. **4I** and FIG. **4J**. In these figures, the first electrode assembly comprises a single pin-like element **232** disposed coaxially with a second electrode array that comprises a single ring-like electrode **242** having a rounded inner opening **246**. However, as indicated by phantom elements **232'**, **242'**, electrode assembly **220** may comprise a plurality of such pin-like and ring-like elements. Preferably electrode **232** is tungsten, and electrode **242** is stainless steel.

Typical dimensions for the embodiment of FIG. **4I** and FIG. **4J** are L1≈10 mm, X1≈9.5 mm, T≈0.5 mm, and the diameter of opening **246** is about 12 mm. Dimension L1 preferably is sufficiently long that upstream portions of electrode **232** (e.g., portions to the left in FIG. **4I**) do not interfere with the electrical field between electrode **232** and the collector electrode **242**. However, as shown in FIG. **4J**, the effect R2/R1 ratio is governed by the tip geometry of electrode **232**. Again, in the preferred embodiment, this ratio exceeds about 20:1. Lines drawn in phantom in FIG. **4J** depict theoretical electric force field lines, emanating from emitter electrode **232**, and terminating on the curved surface of collector electrode **246**. Preferably the bulk of the field emanates within about±45° of coaxial axis between electrode **232** and electrode **242**. On the other hand, if the opening in electrode **242** and/or electrode **232** and **242** geometry is such that too narrow an angle about the coaxial axis exists, air flow will be unduly restricted.

One advantage of the ring-pin electrode assembly configuration shown in FIG. **4I** is that the flat regions of ring-like electrode **242** provide sufficient surface area to which dust entrained in the moving air stream can attach, yet be readily cleaned. As a result, the air stream (OUT) emitted by the hair brush has reduced dust content, especially contrasted to prior art kinetic air mover configurations.

Further, the ring-pin configuration advantageously generates more ozone than prior art configurations, or the configurations of FIGS. **4A–4H**. For example, whereas the configurations of FIGS. **4A–4H** may generate perhaps 50 ppb ozone, the configuration of FIG. **4I** can generate about 2,000 ppb ozone, without an increase in demand upon power supply **B1**.

Nonetheless it will be appreciated that applicants' first array pin electrodes may be utilized with the second array electrodes of FIGS. **4A–4H**. Further, applicants' second array ring electrodes maybe utilized with the first array electrodes of FIGS. **4A–4H**. For example, in modifications of the embodiments of FIGS. **4A–4H**, each wire or columnar electrode **232** is replaced by a column of electrically series-connected pin electrodes (e.g., as shown in FIGS. **4I–4K**), while retaining the second electrode arrays as depicted in these figures. By the same token, in other modifications of the embodiments of FIGS. **4A–4H**, the first array electrodes can remain as depicted, but each of the second array electrodes **242** is replaced by a column of electrically series-connected ring electrodes (e.g., as shown in FIGS. **4I–4K**).

In FIG. **4J**, a detailed cross-sectional view of the central portion of electrode **242** in FIG. **4I** is shown. As best seen in FIG. **4J**, curved region **246** adjacent the central opening in electrode **242** appears to provide an acceptably large surface area to which many ionization paths from the distal tip of electrode **232** have substantially equal path length. Thus, while the distal tip (or emitting tip) of electrode **232** is advantageously small to concentrate the electric field between the electrode arrays, the adjacent regions of electrode **242** preferably provide many equidistant inter-electrode array paths. A high exit flowrate of perhaps 90 feet/minute and 2,000 ppb range ozone emission attainable with this configuration confirm a high operating efficiency.

In FIG. **4K**, one or more electrodes **232** is replaced by a conductive block **232"** of carbon fibers, the block having a distal surface in which projecting fibers **233-1**, . . . **233-N** take on the appearance of a "bed of nails". The projecting fibers can each act as an emitting electrode and provide a plurality of emitting surfaces. Over a period of time, some or all of the electrodes will literally be consumed, whereupon graphite block **232"** will be replaced. Materials other than graphite maybe used for block **232"** providing the material has a surface with projecting conductive fibers such as **233-N**.

FIG. **5** depicts the location of a typical electrode assembly **220** within the head portion of brush **100**, such that second electrode array **240** is closer to the brushing surface of the brush than is first electrode array **230**. While FIG. **5** depicts an electrode assembly **220** using the ring-pin configuration of FIG. **4I**, it is understood that any of the alternative configurations of FIGS. **4A–4G** could instead be contained within brush **100**. FIG. **5** also depicts the optionally removable nature of bristle block **145**, and a different configuration of exit vents **150**. FIG. **5** herein differs from FIG. **5** in the parent application only in the depiction of relatively shorter bristles herein.

Preferably the inner portion of the head region of brush **100** includes an electrostatic shield that reduces detectable electromagnetic radiation outside of the brush. For example, a metal shield could be disposed within the housing, or portions of the interior of the housing could be coated with a metallic paint to reduce such radiation.

It will also be appreciated that the net output of ions could be influenced by placing a bias element near some or all of the output vents. For example, such an element could be electrically biased to neutralize negative ions, thereby increasing the net output of positive ions. It will also be appreciated that the present invention could be adjusted to produce ions without producing ozone, if desired.

Modifications and variations may be made to the disclosed embodiments without departing from the subject and spirit of the invention as defined by the following claims.

What is claimed is:

1. An ion emitting brush, comprising:

a handholdable body including an intake on a first side, a grooming unit on a second side that is opposite the first side, and an outlet extending through the grooming unit;

an ion generator disposed in the body, that creates an electrostatic flow that travels in a downstream direction from the intake to the outlet, including:

a high voltage generator; and

an electrode assembly, electrically coupled with the high voltage generator, the electrode assembly including a first electrode array and a second electrode array, the first electrode array including at least one electrode that has a base and an apex, the base being wider than the apex, and the apex aimed generally in the downstream direction and generally toward the second electrode array, the second electrode array including at least one electrically conductive member through which there is defined at least one opening disposed generally in front of the apex of the at least one electrode of the first electrode array;

wherein the electrostatic flow includes at least one of ionized air and ozone.

2. The ion emitting brush of claim 1, wherein the electrically conductive member comprises a loop of electrically conductive material.

3. The ion emitting brush of claim 2, wherein the opening is generally in a center of the loop of electrically conductive material.

4. The ion emitting brush of claim 1, wherein: precisely one opening is defined in the electrically conductive member generally in front of the apex of the at least one electrode of the first electrode array; and

the electrically conductive member comprises of a loop of electrically conductive material.

5. The ion emitting brush of claim 4, wherein the opening is generally in a center of the loop of electrically conductive material.

6. The ion emitting brush of claim 1, wherein the electrically conductive member includes a surface surrounding the opening and facing the first electrode array.

7. The ion emitting brush of claim 1, wherein the at least one electrode of the first electrode array comprises a cross section that is generally triangular.

8. The ion emitting brush of claim 7, wherein the generally triangular cross section includes two sides that slope toward one another from the base to the apex.

9. The ion emitting brush of claim 1, wherein the at least one electrode of the first electrode array comprises a cross section that tapers from the base to the apex at a substantially constant angle.

10. The ion emitting brush of claim 1, wherein:

the grooming unit comprises a plurality of bristles projecting from the second side.

11. An ion emitting brush, comprising:

a handholdable body including an intake on a first side, a grooming unit on a second side that is opposite the first side, and an outlet extending through the grooming unit;

an ion generator disposed in the body, that creates an electrostatic flow that travels in a downstream direction from the intake to the outlet, including:

a high voltage generator; and

an electrode assembly, electrically coupled with the high voltage generator, the electrode assembly including a first electrode located closer to the intake than the outlet and a second electrode located closer to the outlet than the inlet, the first electrode including a base and an apex, the base being wider than the apex, and the apex aimed generally in the downstream direction and generally toward an opening defined in the second electrode;

wherein the electrostatic flow includes at least one of ionized air and ozone.

12. The ion emitting brush of claim 11, wherein the second electrode comprises a loop of electrically conductive material.

13. The ion emitting brush of claim 12, wherein the opening is generally in a center of the loop of electrically conductive material.

14. The ion emitting brush of claim 11, wherein:

precisely one opening is defined in the second electrode generally in front of the apex of the first electrode; and

the second electrode comprises of a loop of electrically conductive material.

15. The ion emmitting brush of claim 14, wherein the opening is generally in a center of the loop of electrically conductive material.

16. The ion emitting brush of claim 11, wherein the second electrode includes a surface surrounding the opening and facing the first electrode.

17. The ion emitting brush of claim 11, wherein the first electrode comprises across section that is generally triangular.

18. The ion emitting brush of claim 17, wherein the generally triangular cross section includes two sides that slope toward one another from the base to the apex.

19. The ion emitting brush of claim 11, wherein the first electrode comprises a cross section that tapers from the base to the apex at a substantially constant angle.

20. The ion emitting brush of claim 11, wherein:

the grooming unit comprises a plurality of bristles projecting from the second side.

21. An ion emitting brush, comprising:

a handholdable body including an intake, a grooming unit, and an outlet extending through the grooming unit;

an ion generator disposed in the body, that creates an electrostatic flow that travels in a downstream direction from the intake to the outlet, including:

a high voltage generator; and

an electrode assembly, electrically coupled with the high voltage generator, the electrode assembly including a first electrode array and a second electrode array, the first electrode array including at least one electrode that has a base and an apex, the base being wider than the apex, and the apex aimed generally in the downstream direction and generally toward the second electrode array, the second electrode array including at least one electrically conductive member through which there is defined at least one opening disposed generally in front of the apex of the at least one electrode of the first electrode array;

wherein the electrostatic flow includes at least one of ionized air and ozone.

22. The ion emitting brush of claim 21, wherein the electrically conductive member comprises a loop of electrically conductive material.

23. The ion emitting brush of claim 22, wherein the opening is generally in a center of the loop of electrically conductive material.

24. The ion emitting brush of claim 21, wherein:

precisely one opening is defined in the electrically conductive member generally in front of the apex of the at least one electrode of the first electrode array; and

the electrically conductive member comprises of a loop of electrically conductive material.

25. The ion emitting brush of claim 24, wherein the opening is generally in a center of the loop of electrically conductive material.

26. The ion emitting brush of claim 21, wherein the electrically conductive member includes a surface surrounding the opening and facing the first electrode array.

27. The ion emitting brush of claim 21, wherein the at least one electrode of the first electrode array comprises a cross section that is generally triangular.

28. The ion emitting brush of claim 27, wherein the generally triangular cross section includes two sides that slope toward one another from the base to the apex.

29. The ion emitting brush of claim 21, wherein the at least one electrode of the first electrode array comprises a cross section that tapers from the base to the apex at a substantially constant angle.

30. The ion emitting brush of claim 21, wherein:

the grooming unit comprises a plurality of bristles projecting from the second side.

31. An ion emitting brush, comprising:

a handholdable body including an intake, a grooming unit, and an outlet extending through the grooming unit;

an ion generator disposed in the body, that creates an electrostatic flow that travels in a downstream direction from the intake to the outlet, including:

a high voltage generator; and

an electrode assembly, electrically coupled with the high voltage generator, the electrode assembly including a first electrode array and a second electrode array, the first electrode array including at least one electrode that has a tapered distal end aimed generally in the downstream direction and generally toward the second electrode array, the second electrode array including an electrically conductive plate having a curved outer edge;

wherein the electrostatic flow includes at least one of ionized air and ozone.

32. The ion emitting brush of claim 31, wherein an opening is defined in the electrically conductive plate, the opening being disposed generally in front of the tapered distal end of the at least one electrode of the first electrode array.

33. The ion emitting brush of claim 32, wherein the opening is curved.

34. The ion emitting brush of claim 33, wherein the opening has a shape that is similar to the curved outer edge of the electrically conductive plate.

35. The ion emitting brush of claim 32, wherein the electrically conductive plate includes a curved region adjacent to the opening.

36. The ion emitting brush of claim 32, wherein the opening is generally in a center of the electrically conductive plate.

37. The ion emitting brush of claim 33, wherein the electrically conductive plate includes a surface surrounding the opening and facing the first electrode array.

38. The ion emitting brush of claim 31, wherein:

the grooming unit comprises a plurality of bristles projecting from the second side.

39. An ion emitting brush, comprising:

an elongated body including a handle portion and a head portion;

intake vents on a first side of the head portion;

a grooming unit on a second side of the head portion opposite the first side;

outlet vents on the second side of the head portion and extending through the grooming unit; and

an ion generator disposed in the body, that creates a flow that travels in a downstream direction from the intake vents to the outlet vents, including:

a high voltage generator disposed in the body; and

an electrode assembly including a first electrode array electrically coupled with a first output of the high voltage generator and a second electrode array electrically coupled with a second output of the high voltage generator, the first electrode array and the second electrode array disposed in the head portion of the body, the second electrode array closer to the outlet vents than the first electrode array, the first electrode array including an electrode having a tapered distal end aimed generally toward the second electrode array, the second electrode array including an electrically conductive plate having a curved outer edge and through which there is defined an opening disposed generally in front of the tapered distal end of the at least one electrode of the electrode of the first electrode array;

wherein the flow includes at least one of ionized air and ozone.

40. The ion emitting brush of claim 39, wherein the opening is curved.

41. The ion emitting brush of claim 40, wherein the opening has a shape that is similar to the curved outer edge of the electrically conductive plate.

42. The ion emitting brush of claim 39, wherein the electrically conductive plate includes a curved region adjacent to the opening.

43. The ion emitting brush of claim 39, wherein the opening is generally in a center of the electrically conductive plate.

44. The ion emitting brush of claim 39, wherein the electrically conductive plate includes a surface surrounding the opening and facing the first electrode array.

45. The ion emitting brush of claim 39, wherein:

the grooming unit comprises a plurality of bristles projecting from the second side.

* * * * *

US006182671B1

(12) **United States Patent**
Taylor et al.

(10) **Patent No.: US 6,182,671 B1**
(45) **Date of Patent: Feb. 6, 2001**

(54) **ION EMITTING GROOMING BRUSH**

(75) Inventors: **Charles E. Taylor**, Sebastopol; **Shek Fai Lau**, Foster City, both of CA (US)

(73) Assignee: **Sharper Image Corporation**, San Francisco, CA (US)

(*) Notice: Under 35 U.S.C. 154(b), the term of this patent shall be extended for 0 days.

(21) Appl. No.: **09/415,576**

(22) Filed: **Oct. 8, 1999**

Related U.S. Application Data

(63) Continuation of application No. 09/163,024, filed on Sep. 29, 1998, now Pat. No. 5,975,090.

(51) **Int. Cl.**^{7} **A45D 19/16**

(52) **U.S. Cl.** **132/116**; 132/154; 132/272; 15/104.002; 607/79

(58) **Field of Search** 132/112, 116, 132/148, 152, 154, 271, 272; 607/79; 15/104.002, 246.3, 344, 345, 39.5, 40

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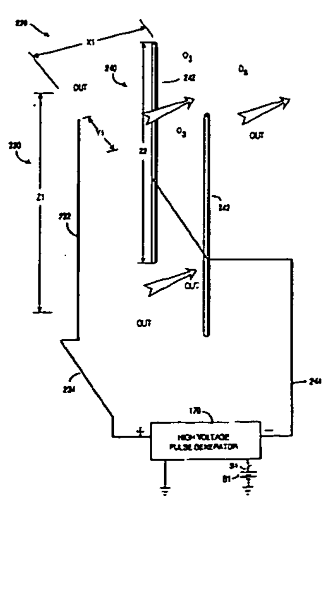
* cited by examiner

Primary Examiner—Todd E. Manahan
(74) *Attorney, Agent, or Firm*—Flehr Hohbach Test Albritton & Herbert LLP

(57) **ABSTRACT**

A brush includes a self-contained ion generator that subjects material being brushed to an outflow of ionized air containing safe amounts of ozone. The ion generator includes a high voltage pulse generator whose output pulses are coupled between first and second electrode arrays. Preferably the first array comprises at least one metal pin spaced coaxially-apart from a metal ring-like structure. Alternatively, the first array may comprise one or more wire electrodes spaced staggeringly apart from a second array comprising hollow "U"-shaped electrodes. Preferably a ratio between effective area of an electrode in the second array compared to effective area of an electrode in the first array exceeds about 15:1 and preferably is about 20:1. An electric field produced by the high voltage pulses between the arrays produces an electrostatic flow of ionized air containing safe amounts of ozone. The outflow of ionized air and ozone is directed between the brush bristles onto the material being brushed.

31 Claims, 13 Drawing Sheets



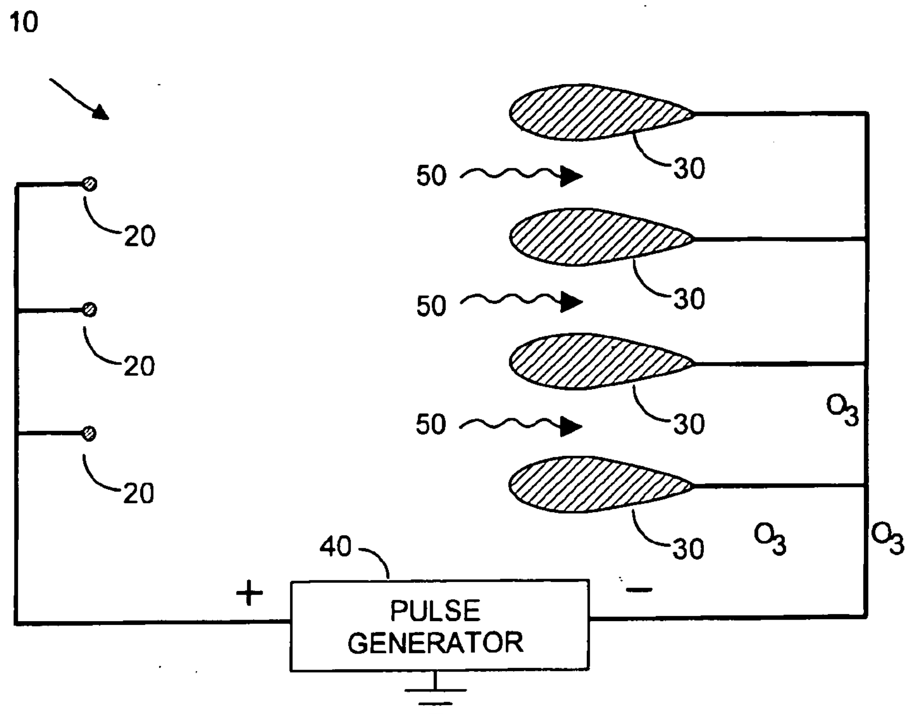


FIG. 1A (PRIOR ART)

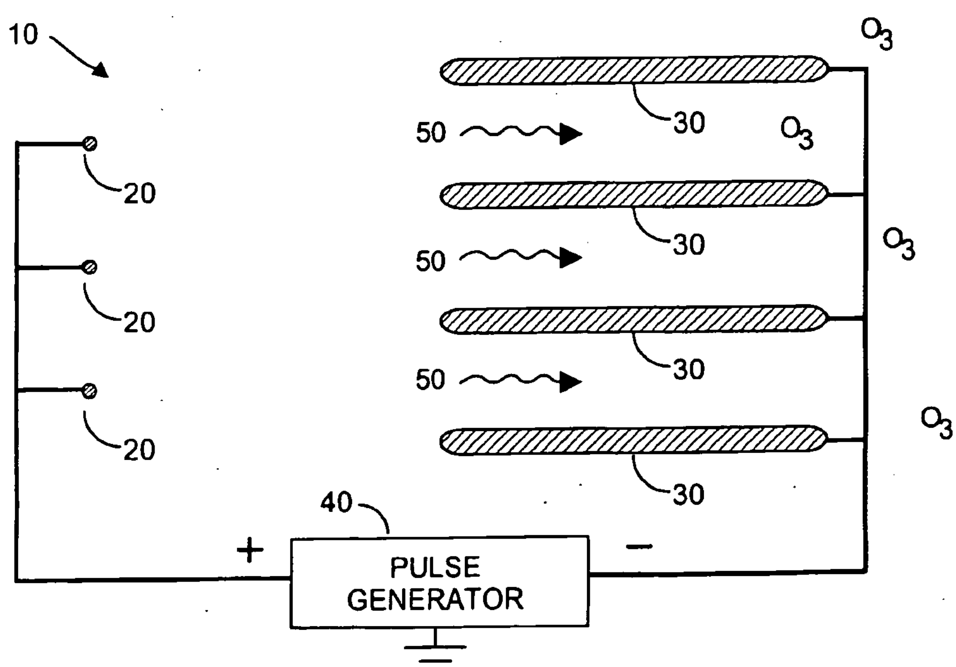
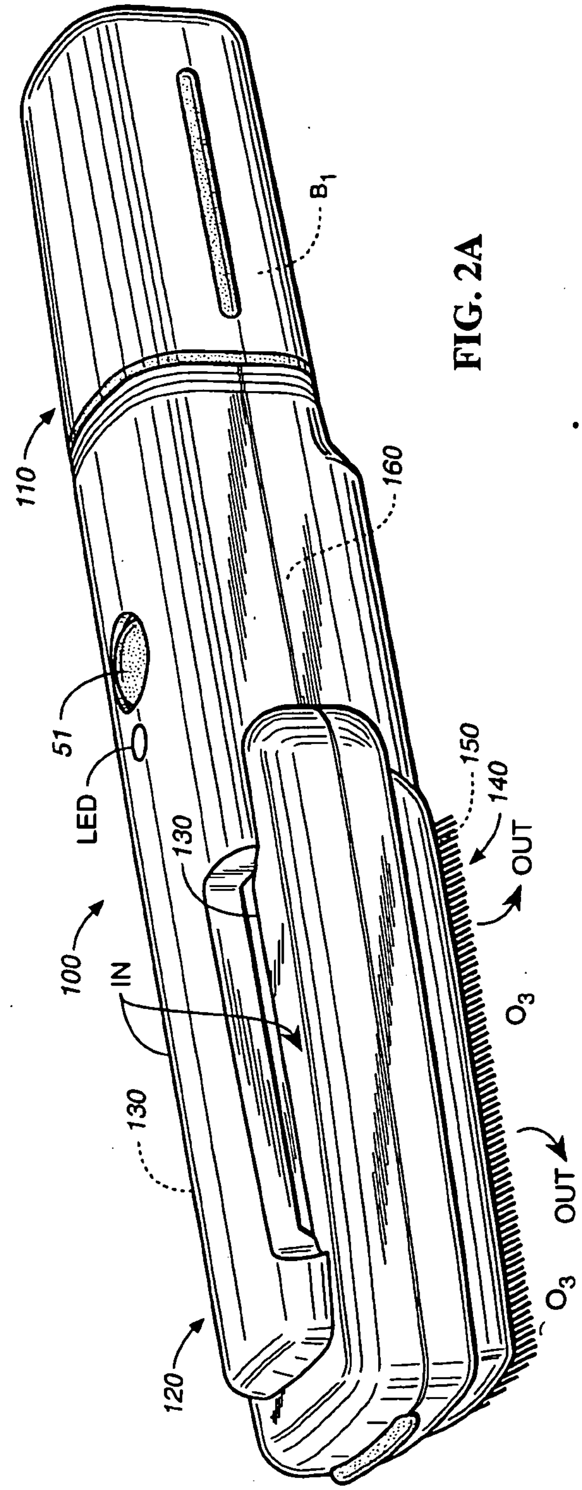
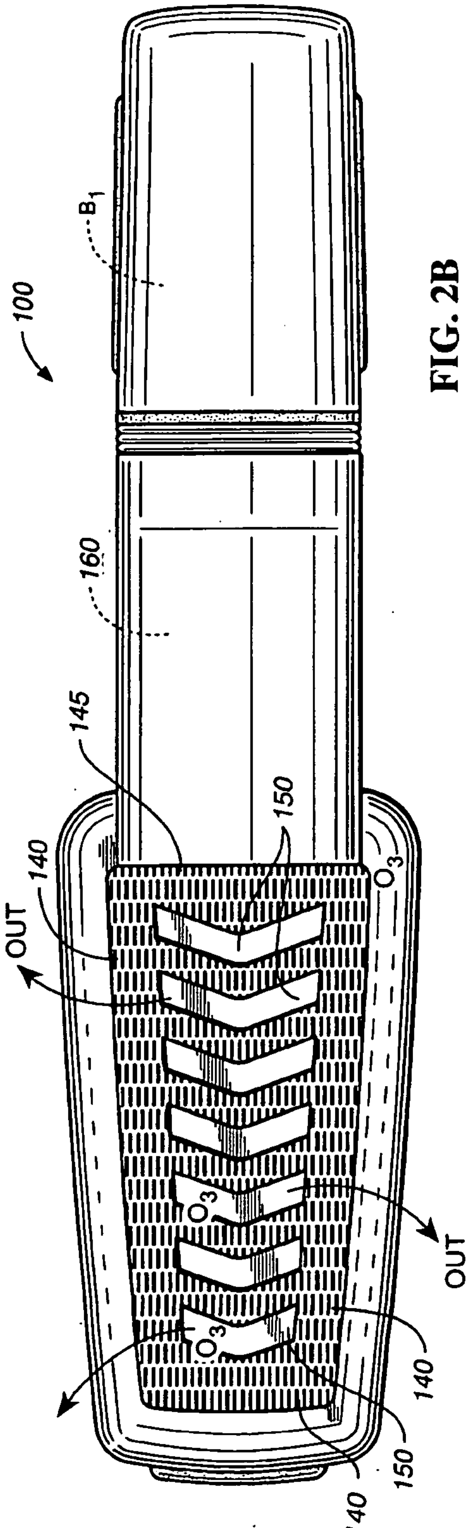


FIG. 1B (PRIOR ART)



110
B1
160
51
LED
130
150
140
OUT
100
IN
O3
130
OUT
O3
120

FIG. 2A



B1
100
160
145
150
140
OUT
O3
O3
OUT
O3
140
140
150
140

FIG. 2B

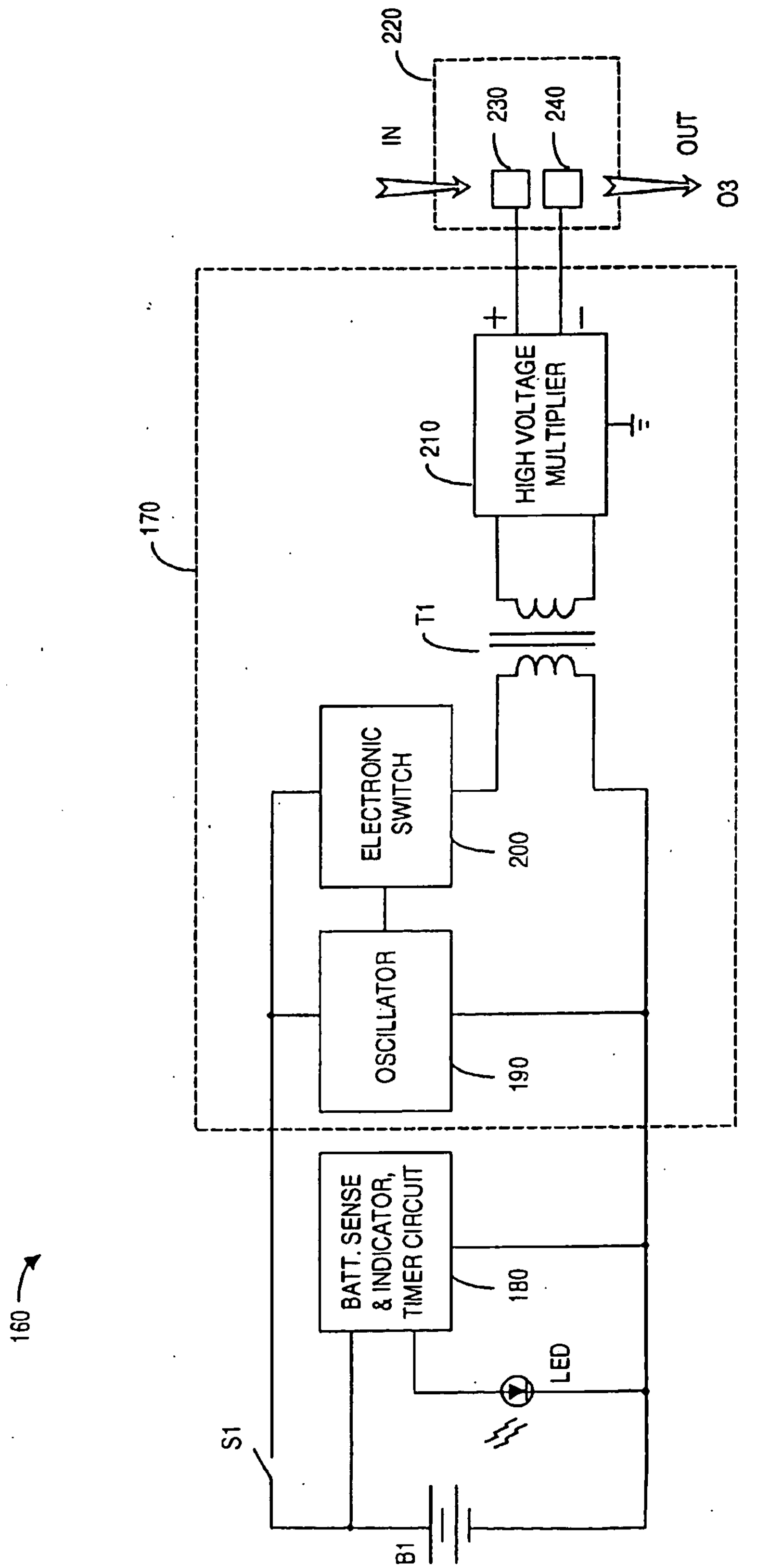

220
IN
230
240
OUT
O3
170
+
−
210
HIGH VOLTAGE MULTIPLIER
T1
ELECTRONIC SWITCH
200
OSCILLATOR
190
BATT. SENSE & INDICATOR, TIMER CIRCUIT
180
LED
160
S1
B1

FIG. 3

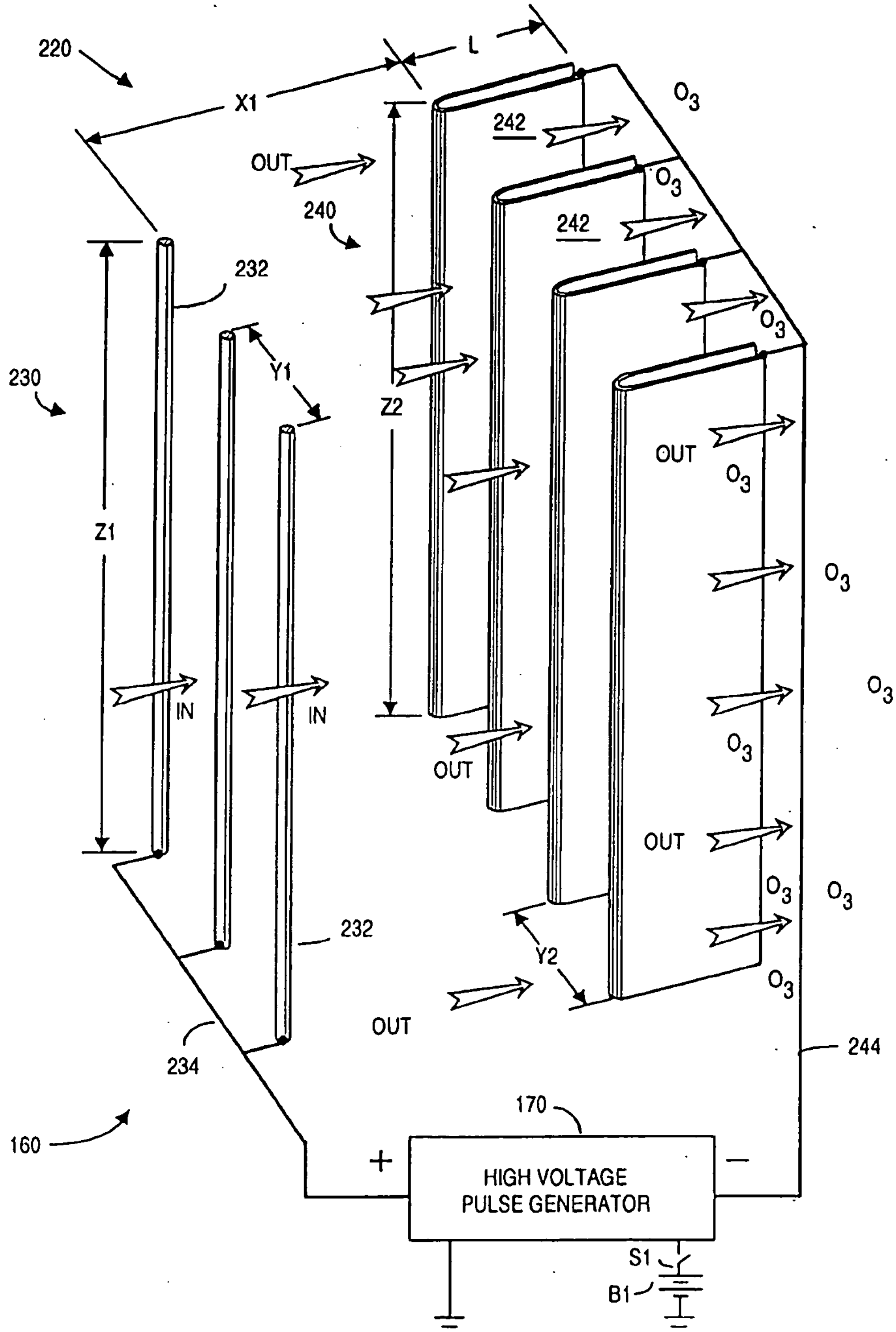

220
L
X1
O_3
242
OUT
O_3
240
242
232
O_3
230
Y1
Z2
OUT
O_3
Z1
O_3
IN
IN
O_3
O_3
OUT
OUT
O_3
O_3
232
Y2
O_3
OUT
234
244
170
160
+
−
HIGH VOLTAGE
PULSE GENERATOR
S1
B1

FIG. 4A

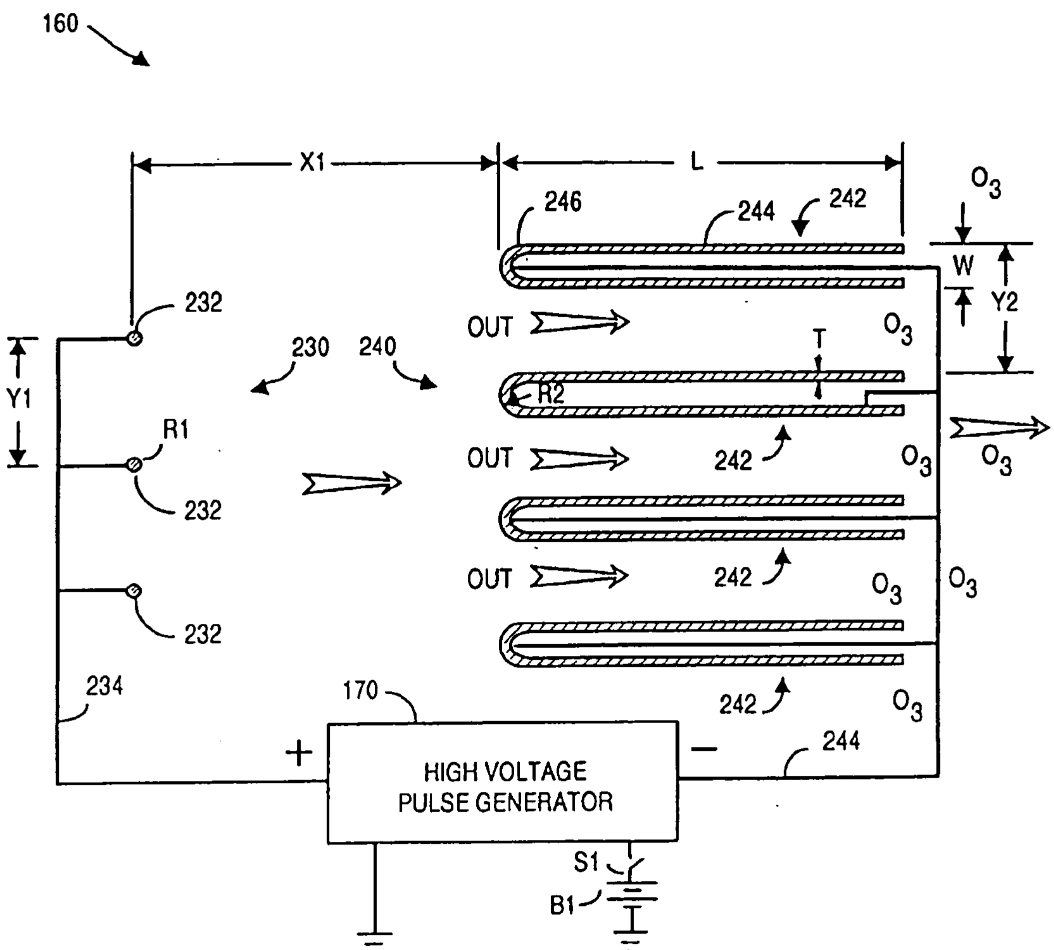

160
X1
L
246
244
242
O_3
W
Y2
232
Y1
OUT
230
240
T
O_3
R2
R1
OUT
242
O_3
O_3
232
OUT
242
O_3
O_3
232
234
170
242
O_3
+
HIGH VOLTAGE
PULSE GENERATOR
−
244
S1
B1

FIG. 4B

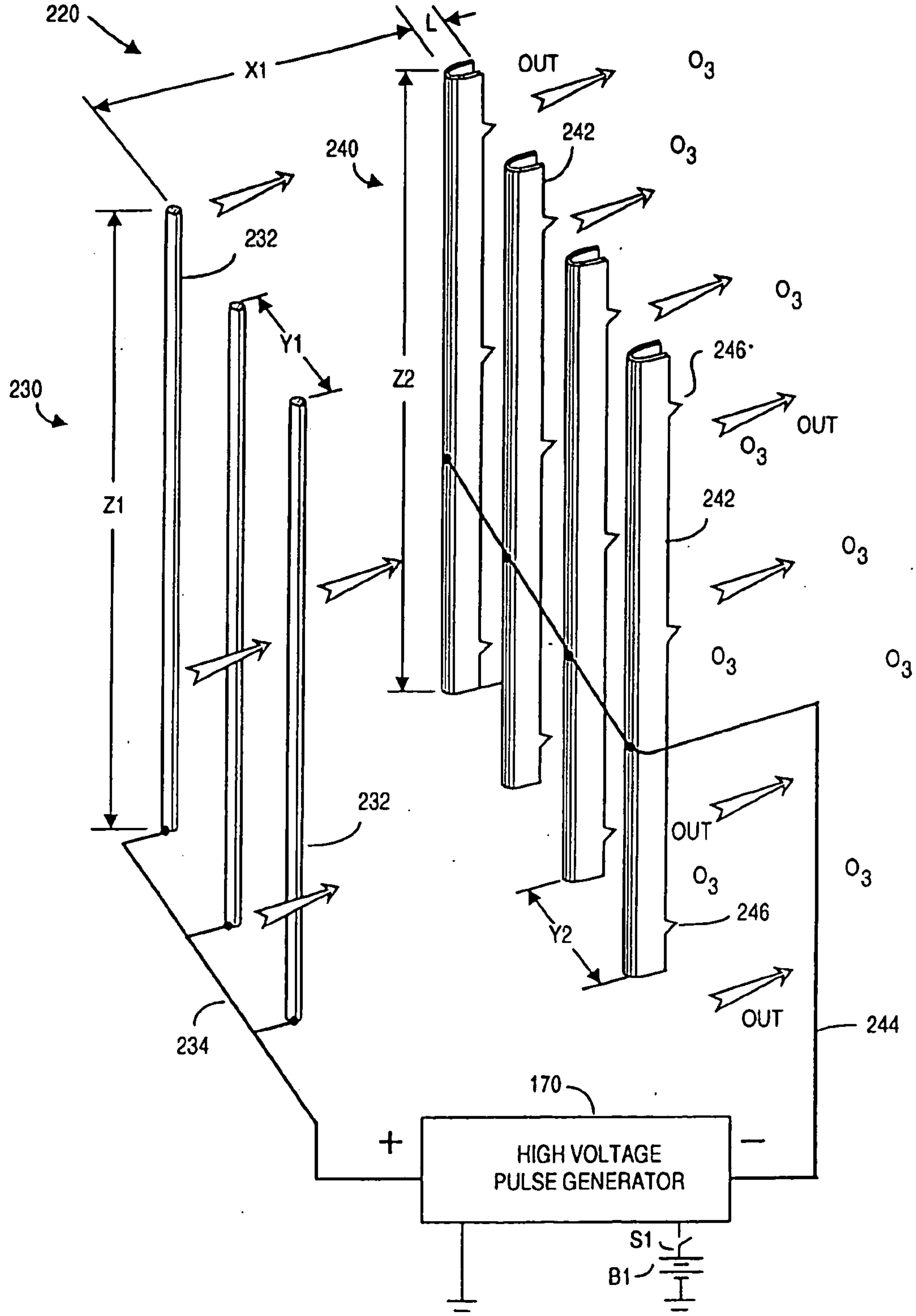

220
X1
L
OUT
O_3
240
242
232
230
Y1
Z2
246
Z1
OUT
242
232
OUT
Y2
246
234
OUT
244
170
+
−
HIGH VOLTAGE
PULSE GENERATOR
S1
B1

FIG. 4C

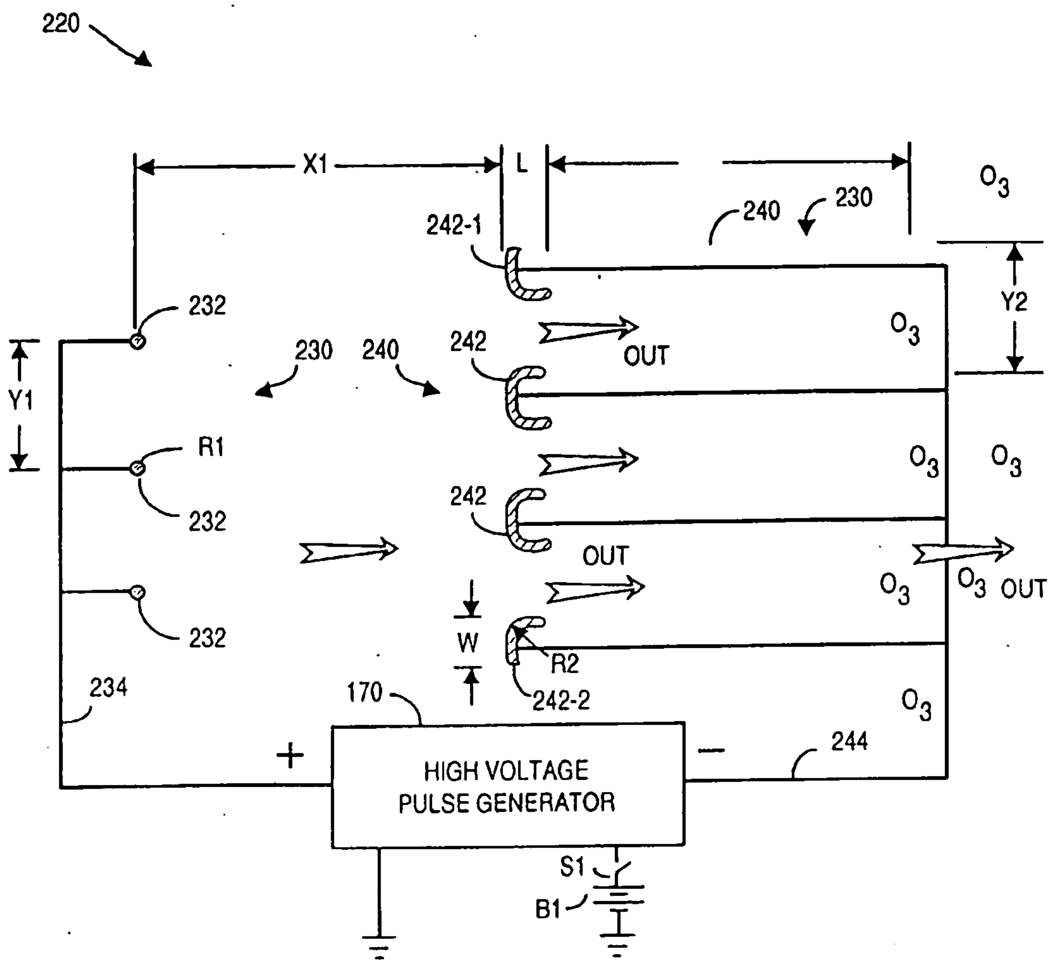

220
X1
L
240
230
O_3
242-1
Y2
232
O_3
230
240
242
OUT
Y1
R1
O_3
O_3
232
242
OUT
O_3
O_3 OUT
W
232
R2
242-2
234
170
O_3
244
+
−
HIGH VOLTAGE
PULSE GENERATOR
S1
B1

FIG. 4D

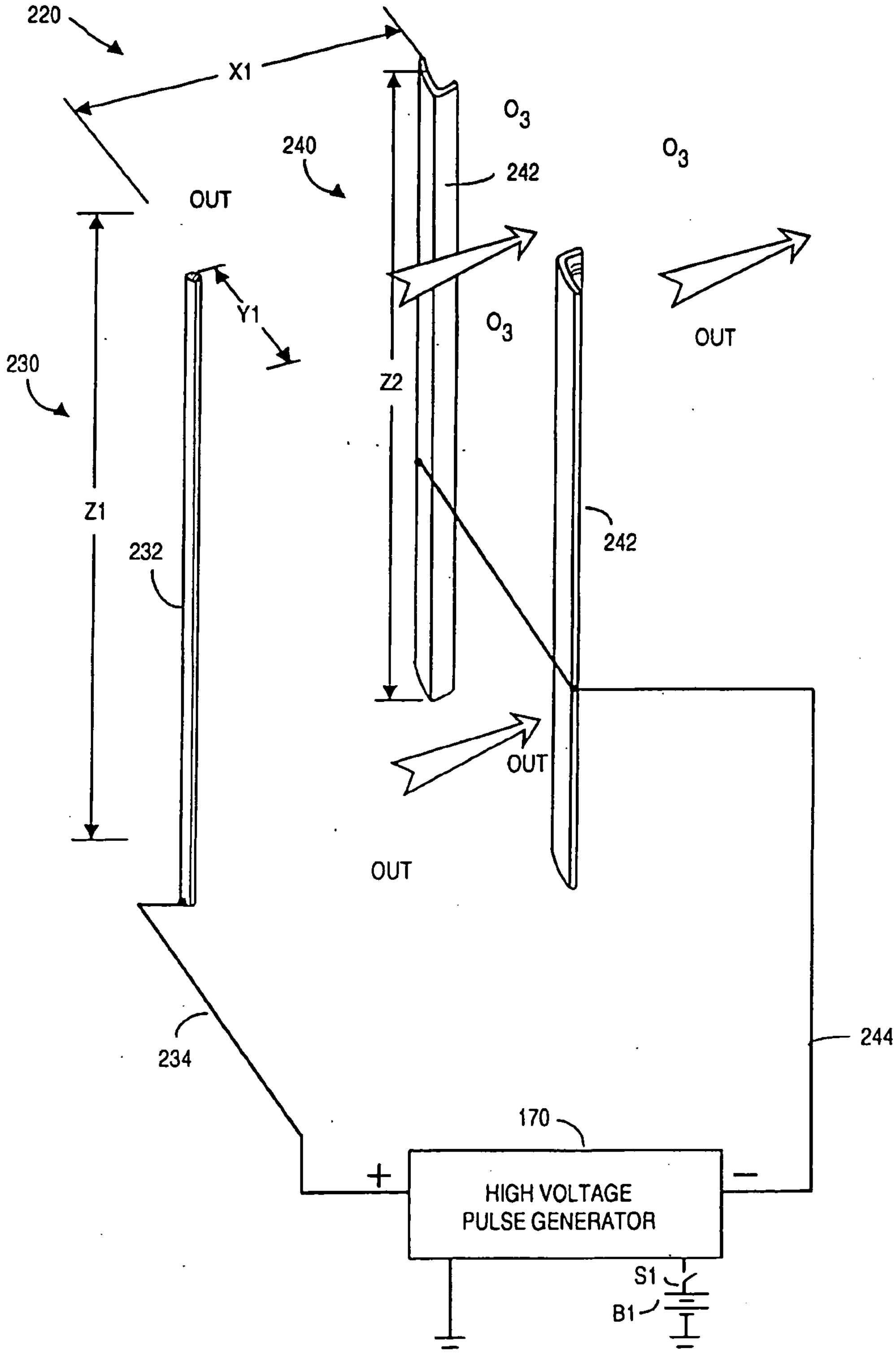

220
X1
240
242
O_3
O_3
OUT
O_3
Y1
230
Z2
OUT
Z1
232
242
OUT
OUT
234
244
170
+
HIGH VOLTAGE
PULSE GENERATOR
−
S1
B1

FIG. 4E

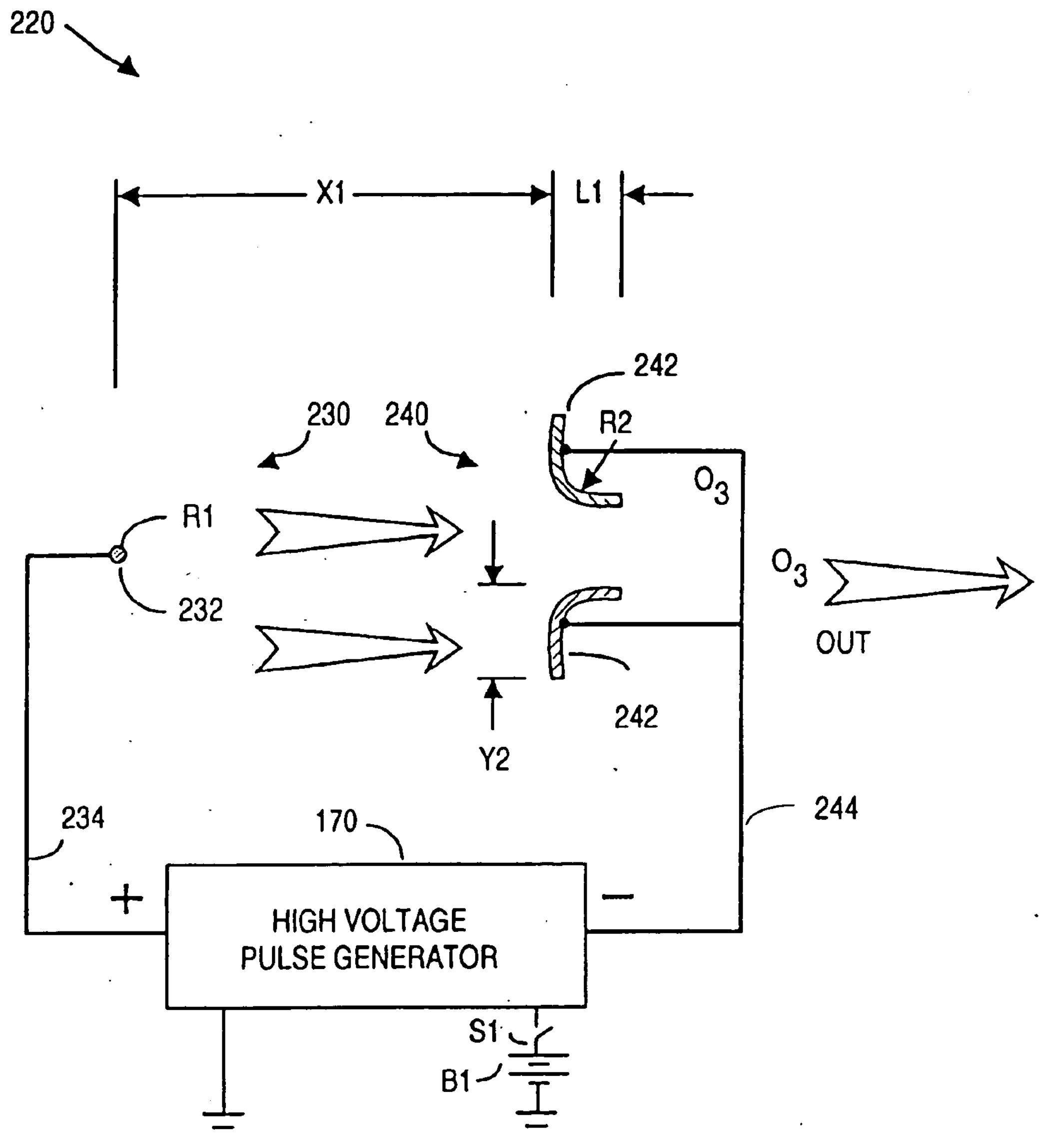

220
X1
L1
242
230
240
R2
O_3
R1
O_3
232
OUT
242
Y2
234
170
244
+
−
HIGH VOLTAGE
PULSE GENERATOR
S1
B1

FIG. 4F

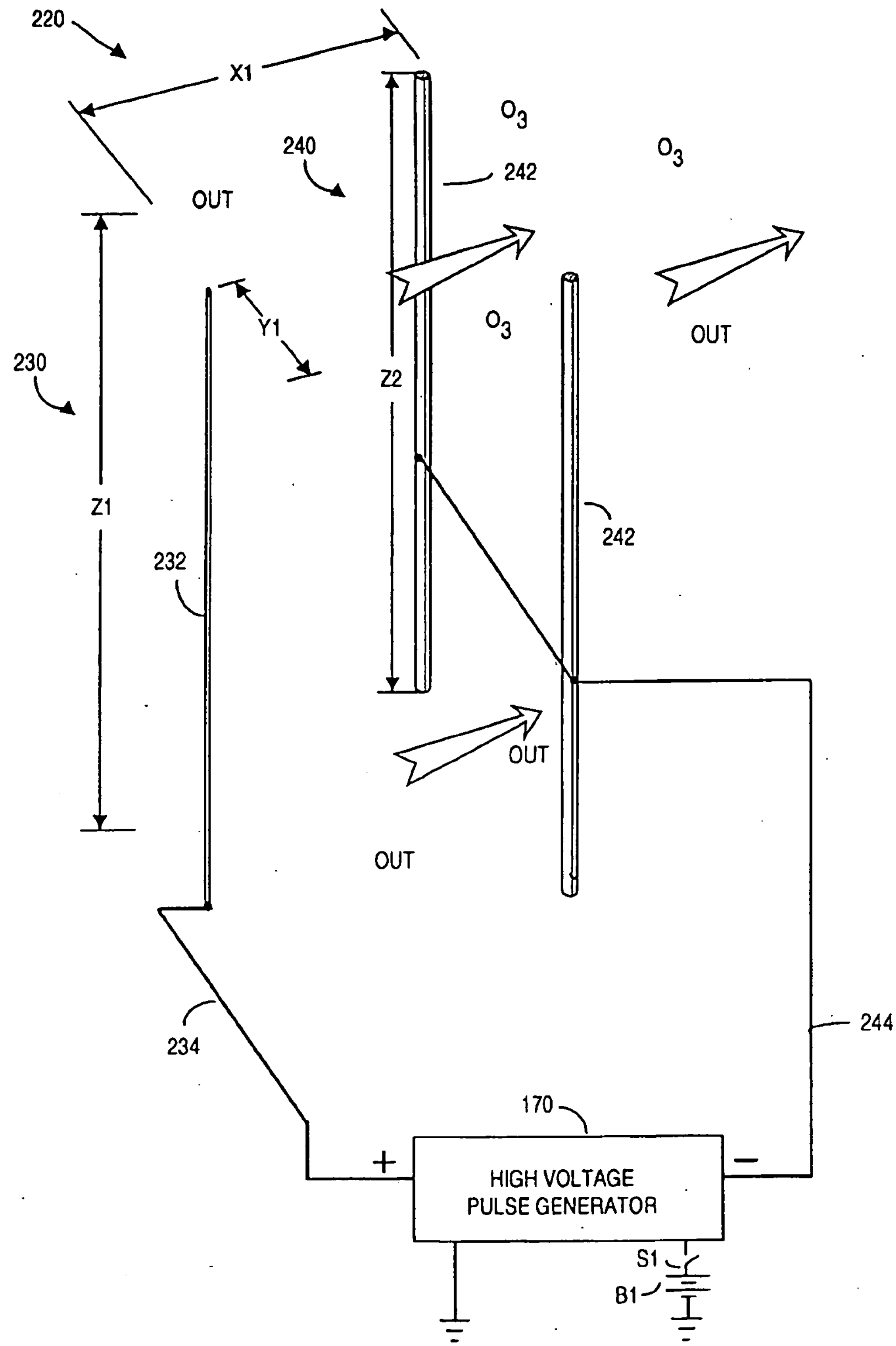

220
X1
240
242
O_3
O_3
OUT
230
Y1
Z2
O_3
OUT
Z1
232
242
OUT
OUT
234
244
170
+
−
HIGH VOLTAGE
PULSE GENERATOR
S1
B1

FIG. 4G

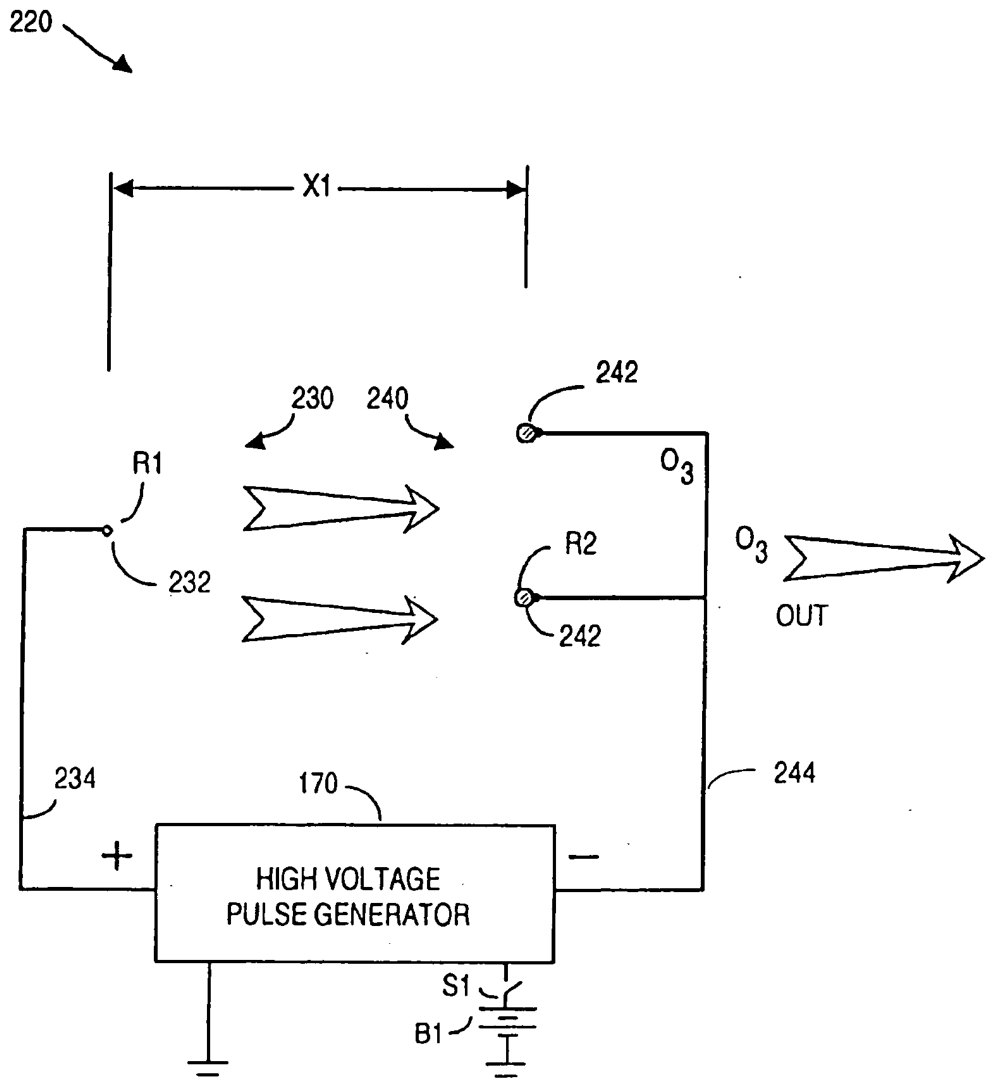

220
X1
230
240
242
R1
O_3
R2
232
O_3
OUT
242
234
170
244
+
−
HIGH VOLTAGE
PULSE GENERATOR
S1
B1

FIG. 4H

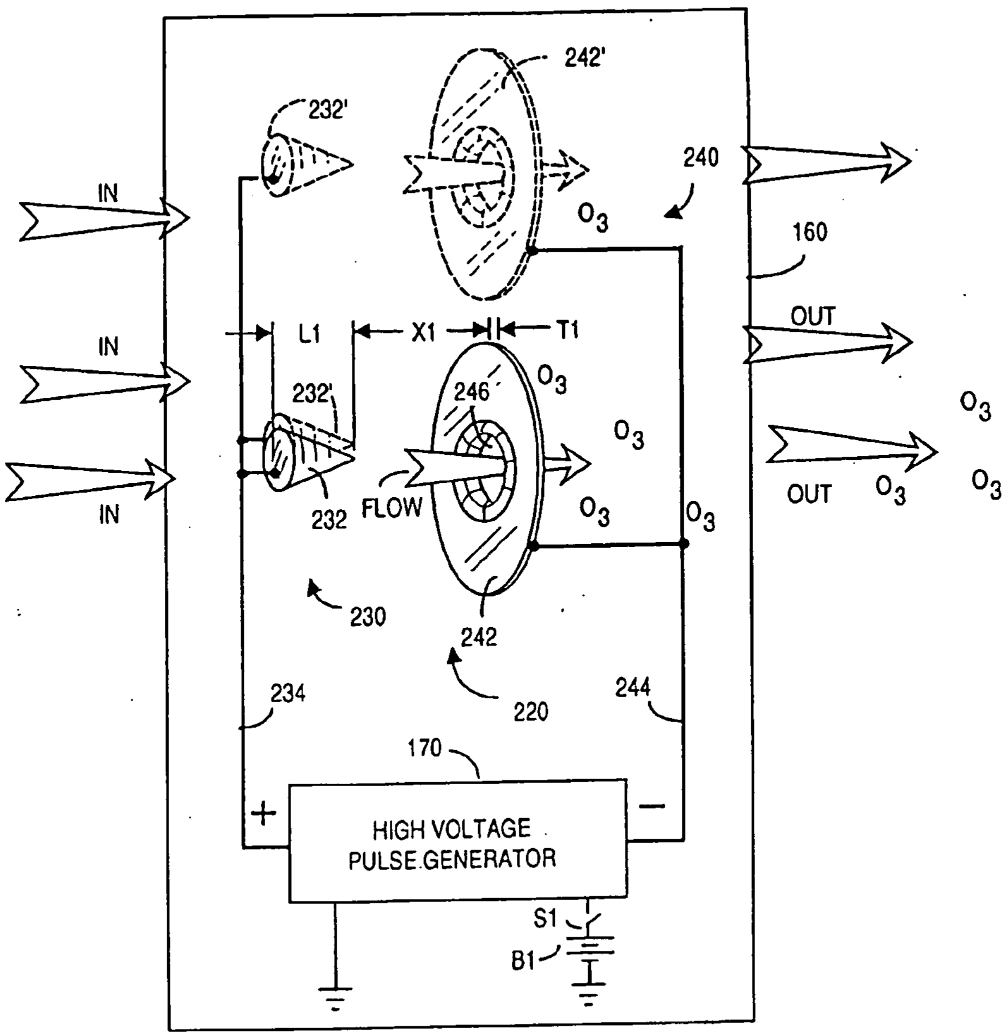


FIG. 4I

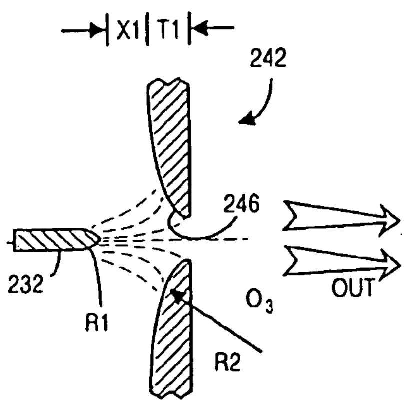


FIG. 4J

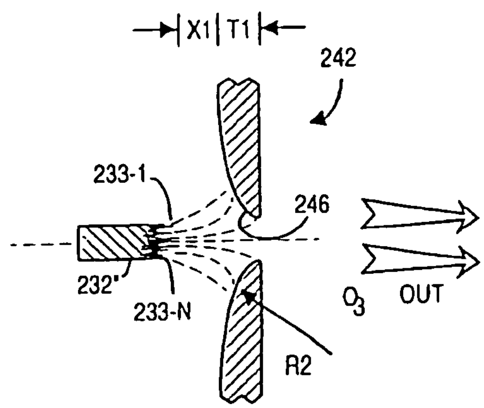


FIG. 4K

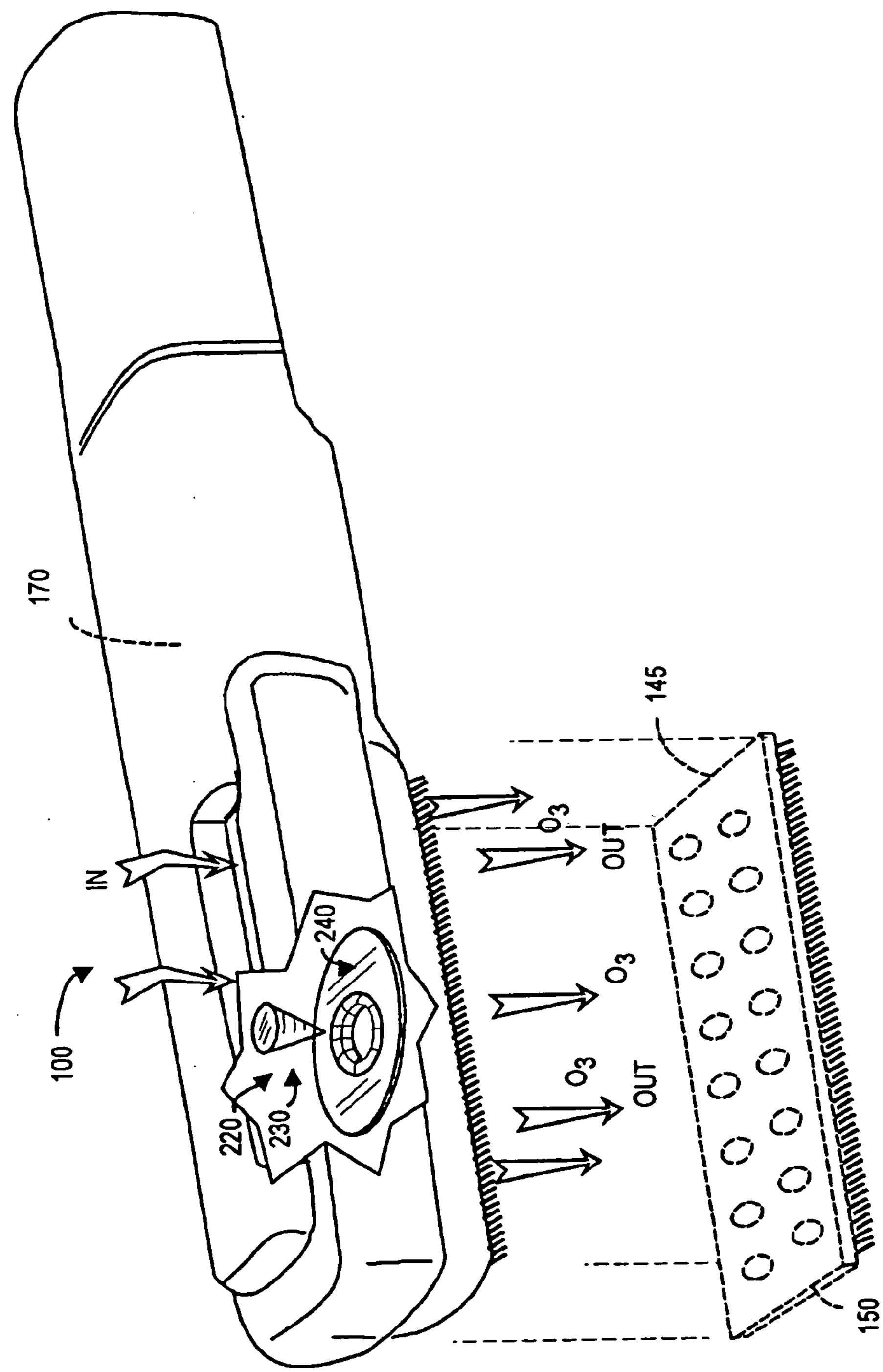


FIG. 5

ION EMITTING GROOMING BRUSH

RELATION TO PENDING APPLICATION

This is a continuing application from application Ser. No. 09/163,024 filed Sep. 29, 1998 entitled "Ion Emitting Grooming Brush", now U.S. Pat. No. 5,975,090 (1999), assigned to the assignee herein, and priority is claimed to said pending application.

FIELD OF THE INVENTION

This invention relates to grooming products and more specifically to brushes that remove hair, lint, etc. from clothing and promote grooming by emitting ionized air directed to the clothing being brushed.

BACKGROUND OF THE INVENTION

However common experience indicates that removing lint, hair, and the like from clothing by conventional brushing is not always successful. For example, static electricity may tend to bind hairs, lint, and other small debris to the surface of clothing. Although brushing one's clothing can mechanically remove some lint, hair, or other particles from the clothing surface, the brushing does not provide any conditioning of the clothing. Too often the lint and other material on the clothing is simply mechanically repositioned.

It is known in the art to produce an air flow electro-kinetically by directly converting electrical power into a flow of air without mechanically moving components. One such system is described in U.S. Pat. No. 4,789,801 to Lee (1988), depicted herein in simplified form as FIGS. 1A and 1B. Lee's system **10** provides a first array of small area ("minisectional") electrodes **20** is spaced-apart symmetrically from a second array of larger area ("maxisectional") electrodes **30**, with a high voltage (e.g., 5 KV) pulse generator **40** coupled between the two arrays. Generator **40** outputs high voltage pulses that ionize the air between the arrays, producing an air flow **50** from the minisectional array toward the maxisectional array results. The high voltage field present between the two arrays can release ozone (O_3), which can advantageously safely destroy many types of bacteria if excessive quantities of ozone are not released.

Unfortunately, Lee's tear-shaped maxisectional electrodes are relatively expensive to fabricate, most likely requiring mold-casting or extrusion processes. Further, air flow and ion generation efficiency is not especially high using Lee's configuration.

There is a need for a brush that can not only brush away lint, hair, etc. from clothing and other material, but provide a measure of cleaning and/or conditioning as well. Preferably such brush should subject the material being brushed to an ion flow to promote cleaning and grooming.

The present invention provides such a grooming brush.

SUMMARY OF THE PRESENT INVENTION

The present invention provides a brush whose body includes a handle portion and a head portion defining at least one vent and including projecting bristles. More preferably, the head portion upperside will define at least one air intake vent and the head portion-underside defines at least one ionized air outlet vent.

Contained within the brush body is a battery-operated ionizer unit with DC battery power supply. The ionizer unit includes a DC:DC inverter that boosts the battery voltage to high voltage, and a pulse generator that receives the high voltage DC and outputs high voltage pulses of perhaps 10 KV peak-to-peak, although high voltage DC could be used instead of pulses. The unit also includes an electrode assembly unit comprising first and second spaced-apart arrays of conducting electrodes, the first array and second array being coupled, respectively, preferably to the positive and negative output ports of the high voltage pulse generator.

The electrode assembly preferably is formed using first and second arrays of readily manufacturable electrode types. In one embodiment, the first array comprises wire-like electrodes and the second array comprises "U"-shaped electrodes having one or two trailing surfaces. In an even more efficient embodiment, the first array includes at least one pin or cone-like electrode and the second array is an annular washer-like electrode. The electrode assembly may comprise various combinations of the described first and second array electrodes. In the various embodiments, the ratio between effective area of the second array electrodes to the first array electrodes is at least about 20:1.

The high voltage pulses create an electric field between the first and second electrode arrays. This field produces an electro-kinetic airflow going from the first array toward the second array, the airflow being rich in ions and in ozone (O_3). Ambient air enters the brush head via air intake vent(s), and ionized air (with ozone) exits the brush through outlet vent(s) in the bristle portion of the head. However, in practice if only one vent is present, it suffices as both an intake and an outlet vent. Preferably a visual indicator is coupled to the ionizer unit to visually confirm to a user when the unit is ready for ionizing operation, and when ionization is actually occurring.

Clothing or other material brushed with the bristles is subjected to a gentle flow of ionized air from the outlet event(s). The brushed material soon takes on a more conditioned appearance, compared to material groomed with an ordinary lint-type brush. The ozone emissions can kill many types of germs and bacteria that may be present on the clothing and can deodorize the clothing surface.

Other features and advantages of the invention will appear from the following description in which the preferred embodiments have been set forth in detail, in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A and 1B are depictions of Lee-type electrostatic generators, according to the prior art;

FIG. 2A is an perspective view of a preferred embodiment of an ionizing brush, according to the present invention;

FIG. 2B is a bottom view of a preferred embodiment of an ionizing brush, according to the present invention;

FIG. 3 is an electrical block diagram of the present invention;

FIG. 4A is a perspective block diagram showing a first embodiment for an electrode assembly, according to the present invention;

FIG. 4B is a plan block diagram of the embodiment of FIG. 4A;

FIG. 4C is a perspective block diagram showing a second embodiment for an electrode assembly, according to the present invention;

FIG. 4D is a plan block diagram of a modified version of the embodiment of FIG. 4C;

FIG. 4E is a perspective block diagram showing a third embodiment for an electrode assembly, according to the present invention;

FIG. 4F is a plan block diagram of the embodiment of FIG. 4E;

FIG. 4G is a perspective block diagram showing a fourth embodiment for an electrode assembly, according to the present invention;

FIG. 4H is a plan block diagram of the embodiment of FIG. 4G;

FIG. 4I is a perspective block diagram showing a fifth embodiment for an electrode assembly, according to the present invention;

FIG. 4J is a detailed cross-sectional view of a portion of the embodiment of FIG. 4I;

FIG. 4K is a detailed cross-sectional view of a portion of an alternative to the embodiment of FIG. 4I;

FIG. 5 is a cutaway perspective view of the present invention showing location of the electrode assembly, according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIGS. 2A and 2B depict an ionized brush 100 according to the present invention as having a body that includes a handle portion 110 and a head portion 120. Head portion 120 includes one or more air intake vents 130, brush bristles 140 that protrude from a brush plate 145 attached to the brushing surface of the brush, and one or more outlet vents 150.

Brush 100 is similar to what was described in FIGS. 2A and 2B in the parent application, except that for a brush to remove lint, hair, etc., bristles 140 will typically be shorter and may be biased at a common angle and formed on a cloth substrate. However whether brush plate 145 includes long bristles or short bristles is unimportant to operation of the present invention.

Internal to the brush body is an ion generating unit 160, powered by a battery B1 (preferably at least 6 VDC) contained within the brush and energizable via a switch S1, preferably mounted on the brush 100. As such, ion generating unit 160 is self-contained in that other than ambient air, nothing is required from beyond the body of the brush for operation of the present invention. Of course if desired, a DC power supply could be disposed external to the brush body, and power brought into the hair brush via a cable.

Preferably handle portion 110 is detachable from head portion 120, to provide access to battery B1, preferably five NiCd rechargeable cells or four disposable cells. The housing material is preferably inexpensive, lightweight, and easy to fabricate, ABS plastic for example. Brush 100 is preferably approximately the size of typical brushes, for example an overall length of perhaps 235 mm, and a maximum width of perhaps 58 mm, although other dimensions can of course be used.

Brush plate 145 may be removably attached to hair brush 100, for ease of cleaning the bristles, for providing access to an ion-emitting electrode assembly within the brush head, as well as for inserting a different brush plate bearing a different type of bristles. Different types or shapes or configurations of bristles might be used interchangeably simply by inserting different brush plate-bristle assemblies into the head portion of the present invention.

It will also be appreciated that use of the present invention is not limited to a single grooming function. Thus, whereas bristles 140 might be fabricated from nylon or plastic for one grooming application, the bristles might instead be metal for use in another application. Thus, if desired, a brush plate 145 containing nylon bristles could be replaced with a different brush plate containing metal bristles.

The ability to remove brush plate 145 also provides ready access to electrodes within the brush head, for purposes of cleaning and, if necessary, replacement. It is to be understood that although FIGS. 2A and 2B depict an exemplary embodiment for brush 100, other configurations may be used. Different configurations of inlet vent(s) 130 and/or outlet vent(s) 150 may be used. Thus, more or fewer such vents may be provided, the locations location and/or shapes of which may differ from what is depicted in FIGS. 2A and 2B. The purpose of vents 130 and 150 is to ensure that an adequate flow of ambient air may be drawn into or made available to unit 130, and that an adequate flow of ionized air that includes safe amounts of O_3 flows out from unit 130 towards the grooming area.

As best seen in FIG. 3, ion generating unit 160 includes a high voltage pulse generator unit 170 and optionally an indicator circuit 180. Circuit 180 senses potential on battery B1 and indicates whether battery potential is sufficient to generate ions and when ion generation is occurring. In the preferred embodiment, a visual indicator is used, preferably a two-color light emitting diode ("LED") Of course other indicator devices may be used, including for example, blinking indicator(s), and/or audible indicator(s). Optionally, circuit 180 includes timing components that will turn-off generation of ions and ozone after a predetermined time, for example two minutes. Such a turn-off feature will preserve battery lifetime in the event S1 is other than a push-to-maintain contact type switch. Thus, a user who pushes S1 and uses the brush but forgets to turn-off S1 will not necessarily deplete battery B1, as circuitry 180 will turn-off the present invention for the user.

As shown in FIG. 3, high voltage pulse generator unit 170 preferably comprises a low voltage oscillator circuit 190 of perhaps 20 KHz frequency, that outputs low voltage pulses to an electronic switch 200, e.g., a thyristor or the like. Switch 200 switchably couples the low voltage pulses to the input winding of a step-up transformer T1. The secondary winding of T1 is coupled to a high voltage multiplier circuit 210 that outputs high voltage pulses. Preferably the circuitry and components comprising high voltage pulse generator 170 and sense/indicator circuit (and timing circuit) 180 are fabricated on a printed circuit board that is mounted within head portion 120 of hair brush 100.

Output pulses from high voltage generator 170 preferably are at least 10 KV peak-to-peak with an effective DC offset of perhaps half the peak-to-peak voltage, and have a frequency of perhaps 20 KHz. The pulse train output preferably has a duty cycle of perhaps 10%, which will promote battery lifetime. Of course, different peak-peak amplitudes, DC offsets, pulse train waveshapes, duty cycle, and/or repetition frequencies may instead be used. Indeed, a 100% pulse train (e.g., an essentially DC high voltage) may be used, albeit with shorter battery lifetime.

Frequency of oscillation is not especially critical but frequency of at least about 20 KHz is preferred as being inaudible to humans. However if brush 100 is intended for use in the immediate vicinity of pets, even higher operating frequency may be desired such that the present invention does not emit audible sounds that would disturb nearby animals.

The output from high voltage pulse generator unit 170 is coupled to an electrode assembly 220 that comprises a first electrode array 230 and a second electrode array 240. Unit 170 functions as a DC:DC high voltage generator, and could be implemented using other circuitry and/or techniques to output high voltage pulses that are input to electrode assembly 220.

In the embodiment of FIG. 3, the positive output terminal of unit **170** is coupled to first electrode array **230**, and the negative output terminal is coupled to second electrode array **240**. This coupling polarity has been found to work well. An electrostatic flow of air is created, going from the first electrode array towards the second electrode array. (This flow is denoted "OUT" in the figures.) Accordingly electrode assembly **220** is mounted in the head portion **120** of brush **100** such that second electrode array **240** is closer to the brushing surface (e.g., bristle-containing region where outlet vent(s) **150** are located) than is first electrode array **230**.

When voltage or pulses from high voltage pulse generator **170** are coupled across first and second electrode arrays **230** and **240**, it is believed that a plasma-like field is created surrounding electrodes **232** in first array **230**. This electric field ionizes the air between the first and second electrode arrays and establishes an "OUT" airflow that moves towards the second array. It is understood that the IN flow enters brush **100** via vent(s) **130**, and that the OUT flow exits brush **100** via vent(s) **150**.

It is believed that ozone and ions are generated simultaneously by the first array electrode(s) **232**, essentially as a function of the potential from generator **170** coupled to the first array. Ozone generation may be increased or decreased by increasing or decreasing the potential at the first array. Coupling an opposite polarity potential to the second array electrode(s) **242** essentially accelerates the motion of ions generated at the first array, producing the air flow denoted as "OUT" in the figures. As the ions move toward the second array, it is believed that they push or move air molecules toward the second array. The relative velocity of this motion may be increased by decreasing the potential at the second array relative to the potential at the first array.

For example, if +10 KV were applied to the first array electrode(s), and no potential were applied to the second array electrode(s), a cloud of ions (whose net charge is positive) would form adjacent the first electrode array. Further, the relatively high 10 KV potential would generate substantial ozone. By coupling a relatively negative potential to the second array electrode(s), the velocity of the air mass moved by the net emitted ions increases, as momentum of the moving ions is conserved.

On the other hand, if it were desired to maintain the same effective outflow (OUT) velocity but to generate less ozone, the exemplary 10 KV potential could be divided between the electrode arrays. For example, generator **170** could provide +6 KV (or some other fraction) to the first array electrode(s) and −4 KV (or some other fraction) to the second array electrode(s). In this example, it is understood that the +6 KV and the −4 KV are measured relative to ground. Understandable it is desired that the present invention operate to output safe amounts of ozone.

As noted, outflow (OUT) preferably includes safe amounts of O_3 that can destroy or at least substantially alter bacteria, germs, and other living (or quasi-living) matter subjected to the outflow. Thus, when switch Sl is closed and B1 has sufficient operating potential, pulses from high voltage pulse generator unit **170** create an outflow (OUT) of ionized air and O_3. When S1 is closed, LED will first visually signal whether sufficient B1 potential is present, and if present, then signal when ionization is occurring. If LED fails to indicate sufficient operating voltage, the user will know to replace B1 or, if rechargeable cells are used, to recharge B1. For example, if visual indicator is a two-color device, the LED could signal red when B1 potential exceeds a minimum threshold, e.g., 5.5 VDC. Further, LED could then signal green when S1 is depressed and unit **160** is actually outputting ionized air. If the battery potential is too low, the LED will not light, which advises the user to replace or re-charge battery source **B1**.

Preferably operating parameters of the present invention are set during manufacture and are not user-adjustable. For example, increasing the peak-to-peak output voltage and/or duty cycle in the high voltage pulses generated by unit **170** can increase air flowrate, ion content, and ozone content. In the preferred embodiment, output flowrate is about **90** feet/minute, ion content is about 2,000,000/cc and ozone content is about 50 ppb (over ambient) to perhaps 2,000 ppb (over ambient). Decreasing the R2/R1 ratio below about 20:1 will decrease flow rate, as will decreasing the peak-to-peak voltage and/or duty cycle of the high voltage pulses coupled between the first and second electrode arrays.

In practice, a user holds and uses brush **100** in conventional fashion to brush clothing or other material. With S1 energized, ionization unit **160** emits ionized air and preferably some ozone (O_3) via outlet vents **150**. The material being groomed advantageously is subjected to this outflow ("OUT") of air and ozone. Beneficially, the brushed material seems to align together more coherently than when using a non-ionized brush.

Odors in the material being brushed will diminish, and some types of germs or bacteria, if present, can be killed by the outflow from brush **100**. In short, not only is the material brushed and groomed more effectively than with a passive prior art brush, e.g., a brush that does not actively emit ions, but hygiene is promoted as well.

Having described various aspects of the invention in general, preferred embodiments of electrode assembly **220** will now be described. In the various embodiments, electrode assembly **220** will comprise a first array **230** of at least one electrode **232**, and will further comprise a second array **240** of preferably at least one electrode **242**. Understandably material(s) for electrodes **232** and **242** should conduct electricity, be resilient to corrosive effects from the application of high voltage, yet be strong enough to be cleaned.

In the various electrode assemblies to be described herein, electrode(s) **232** in the first electrode array **230** are preferably fabricated from tungsten. Tungsten is sufficiently robust to withstand cleaning, has a high melting point to retard breakdown due to ionization, and has a rough exterior surface that seems to promote efficient ionization. On the other hand, electrodes **242** preferably will have a highly polished exterior surface to minimize unwanted point-to-point radiation. As such, electrodes **242** preferably are fabricated from stainless steel, brass, among other materials. The polished surface of electrodes **232** also promotes ease of electrode cleaning.

In contrast to the prior art electrodes disclosed by Lee, electrodes **232** and **242** according to the present invention are light weight, easy to fabricate, and lend themselves to mass production. Further, electrodes **232** and **242** described herein promote more efficient generation of ionized air, and production of safe amounts of ozone, O_3.

In the present invention, a high voltage pulse generator **170** is coupled between the first electrode array **230** and the second electrode array **240**. The high voltage pulses produce a flow of ionized air that travels in the direction from the first array towards the second array (indicated herein by hollow arrows denoted "OUT"). As such, electrode(s) **232** may be referred to as an emitting electrode, and electrodes **242** may be referred to as collector electrodes. This outflow advan-

tageously contains safe amounts of O_3, and exits the present invention from vent(s) **150**, as shown in FIGS. **2**A and **2**B. Although a generator of high voltage pulses is preferred and will promote battery life, in practice high voltage DC (e.g., pulses having 100% duty cycle) may instead be used.

According to the present invention, it is preferred that the positive output terminal or port of the high voltage pulse generator be coupled to electrodes **232**, and that the negative output terminal or port be coupled to electrodes **242**. It is believed that the net polarity of the emitted ions is positive, e.g., more positive ions than negative ions are emitted. In any event, the preferred electrode assembly electrical coupling minimizes audible hum from electrodes **232** contrasted with reverse polarity (e.g., interchanging the positive and negative output port connections). Further, the preferred electrical coupling seems to produce ions that help keep hair in place, as opposed to putting a static charge into the hair that can produce an undesired "fly-away" hair appearance. In some embodiments, however, one port (preferably the negative port) of high voltage pulse generator may in fact be the ambient air. Thus, electrodes in the second array need not be connected to the high voltage pulse generator using wire. Nonetheless, there will be an "effective connection" between the second array electrodes and one output port of the high voltage pulse generator, in this instance, via ambient air.

Turning now to the embodiments of FIGS. **4**A and **4**B, electrode assembly **220** comprises a first array **230** of wire electrodes **232**, and a second array **240** of generally "U"-shaped electrodes **242**. In preferred embodiments, the number N1 of electrodes comprising the first array will differ by one relative to the number N2 of electrodes comprising the second array. In many of the embodiments shown, N2>N1. However, if desired, in FIG. **4**A, addition first electrodes **232** could be added at the out ends of array **230** such that N1>N2, e.g., five electrodes **232** compared to four electrodes **242**.

Electrodes **232** are preferably lengths of tungsten wire, whereas electrodes **242** are formed from sheet metal, preferably stainless steel, although brass or other sheet metal could be used. The sheet metal is readily formed to define side regions **244** and bulbous nose region **246** for hollow elongated "U" shaped electrodes **242**. While FIG. **4**A depicts four electrodes **242** in second array **240** and three electrodes **232** in first array **230**, as noted, other numbers of electrodes in each array could be used, preferably retaining a symmetrically staggered configuration as shown.

As best seen in FIG. **4**B, the spaced-apart configuration between the arrays is staggered such that each first array electrode **232** is substantially equidistant from two second array electrodes **242**. This symmetrical staggering has been found to be an especially efficient electrode placement. Preferably the staggering geometry is symmetrical in that adjacent electrodes **232** or adjacent electrodes **242** are spaced-apart a constant distance, Y1 and Y2 respectively. However, a non-symmetrical configuration could also be used, although ion emission and air flow would likely be diminished. Also, it is understood that the number of electrodes **232** and **242** may differ from what is shown.

In FIGS. **4**A, typically dimensions are as follows: diameter of electrodes **232** is about 0.08 mm, distances Y1 and Y2 are each about 16 mm, distance X1 is about 16 mm, distance L is about 20 mm, and electrode heights Z1 and Z2 are each about 100 mm. The width W of electrodes **242** is preferably about 4 mm, and the thickness of the material from which electrodes **242** are formed is about 0.5 mm. Of course other dimensions and shapes could be used. It is preferred that electrodes **232** be small in diameter to help establish a desired high voltage field. On the other hand, it is desired that electrodes **232** (as well as electrodes **242**) be sufficiently robust to withstand occasional cleaning.

Electrodes **232** in first array **230** are coupled by a conductor **234** to a first (preferably positive) output port of high voltage pulse generator **170**, and electrodes **242** in second array **240** are coupled by a conductor **244** to a second (preferably negative) output port of generator **170**. It is relatively unimportant where on the various electrodes electrical connection is made to conductors **234** or **244**. Thus, by way of example FIG. **413** depicts conductor **244** making connection with some electrodes **242** internal to bulbous end **246**, while other electrodes **242** make electrical connection to conductor **244** elsewhere on the electrode. Electrical connection to the various electrodes **242** could also be made on the electrode external surface providing no substantial impairment of the outflow airstream results.

The ratio of the effective electric field emanating area of electrode **232** to the nearest effective area of electrodes **242** is at least about 15:1, and preferably is at least 20:1. Beyond a ratio of say 35:1, little or no performance improvement results. Thus, in the embodiment of FIG. **4**A and FIG. **4**B, the ratio R2/R1≈2 mm/0.08 mm≈25:1.

In this and the other embodiments to be described herein, ionization appears to occur at the smaller electrodes) **232** in the first electrode array **230**, with ozone production occurring as a function of high voltage arcing. For example, increasing the peak-to-peak voltage amplitude and/or duty cycle of the pulses from the high voltage pulse generator **170** can increase ozone content in the output flow of ionized air.

In the embodiment of FIGS. **4**A and **4**C, each "U"-shaped electrode **242** has two trailing edges **244** that promote efficient kinetic transport of the outflow of ionized air and O_3. By contrast, the embodiments of FIGS. **4**C and **4**D depict somewhat truncated versions of electrodes **242**. Whereas dimension L in the embodiment of FIGS. **4**A and **4**B was about 20 mm, in FIGS. **4**C and **4**D, L has been shortened to about 8 mm. Other dimensions in FIG. **4**C preferably are similar to those stated for FIGS. **4**A and **4**B. In FIGS. **4**C and **4**D, the inclusion of point-like regions **246** on the trailing edge of electrodes **242** seems to promote more efficient generation of ionized air flow. It will be appreciated that the configuration of second electrode array **240** in FIG. **4**C can be more robust than the configuration of FIGS. **4**A and **4**B, by virtue of the shorter trailing edge geometry. As noted earlier, a symmetrical staggered geometry for the first and second electrode arrays is preferred for the configuration of FIG. **4**C.

In the embodiment of FIG. **4**D, the outermost second electrodes, denoted **242-1** and **242-2**, have substantially no outermost trailing edges. Dimension L in FIG. **4**D is preferably about 3 mm, and other dimensions may be as stated for the configuration of FIGS. **4**A and **4**B. Again, the R2/R1 ratio for the embodiment of FIG. **4**D preferably exceeds about 20:1.

FIGS. **4**E and **4**F depict another embodiment of electrode assembly **220**, in which the first electrode array comprises a single wire electrode **232**, and the second electrode array comprises a single pair of curved "L" shaped electrodes **242**, in cross-section. Typical dimensions, where different than what has been stated for earlier-described embodiments, are X1≈12 mm, Y1≈6 mm, Y2≈3 mm, and L1≈3 mm. The effective R2/R1 ratio is again greater than about 20:1. The fewer electrodes comprising assembly **220** in FIGS. **4**E and **4**F promote economy of construction, and ease of cleaning,

although more than one electrode 232, and more than two electrodes 242 could of course be employed. This embodiment again incorporates the staggered symmetry described earlier, in which electrode 232 is equidistant from two electrodes 242.

FIG. 4G and 4H shown yet another embodiment for electrode assembly 220. In this embodiment, first electrode array 230 is a length of wire 232, while the second electrode array 240 comprises a pair of rod or columnar electrodes 242. As in embodiments described earlier herein, it is preferred that electrode 232 be symmetrically equidistant from electrodes 242. Wire electrode 232 is preferably perhaps 0.08 mm tungsten, whereas columnar electrodes 242 are perhaps 2 mm diameter stainless steel. Thus, in this embodiment the R2/R1 ratio is about 25:1. Other dimensions may be similar to other configurations, e.g., FIG. 4E, 4F. Of course electrode assembly 220 may comprise more than one electrode 232, and more than two electrodes 242.

An especially preferred embodiment is shown in FIG. 4I and FIG. 4J. In these figures, the first electrode assembly comprises a single pin-like element 232 disposed coaxially with a second electrode array that comprises a single ring-like electrode 242 having a rounded inner opening 246. However, as indicated by phantom elements 232', 242', electrode assembly 220 may comprise a plurality of such pin-like and ring-like elements. Preferably electrode 232 is tungsten, and electrode 242 is stainless steel.

Typical dimensions for the embodiment of FIG. 4I and FIG. 4J are L1~10 mm, X1~9.5 mm, T~0.5 mm, and the diameter of opening 246 is about 12 mm. Dimension L1 preferably is sufficiently long that upstream portions of electrode 232 (e.g., portions to the left in FIG. 4I) do not interfere with the electrical field between electrode 232 and the collector electrode 242. However, as shown in FIG. 4J, the effect R2/R1 ratio is governed by the tip geometry of electrode 232. Again, in the preferred embodiment, this ratio exceeds about 20:1. Lines drawn in phantom in FIG. 4J depict theoretical electric force field lines, emanating from emitter electrode 232, and terminating on the curved surface of collector electrode 246. Preferably the bulk of the field emanates within about ±420 of coaxial axis between electrode 232 and electrode 242. On the other hand, if the opening in electrode 242 and/or electrode 232 and 242 geometry is such that too narrow an angle about the coaxial axis exists, air flow will be unduly restricted.

One advantage of the ring-pin electrode assembly configuration shown in FIG. 4I is that the flat regions of ring-like electrode 242 provide sufficient surface area to which dust entrained in the moving air stream can attach, yet be readily cleaned. As a result, the air stream (OUT) emitted by the hair brush has reduced dust content, especially contrasted to prior art kinetic air mover configurations.

Further, the ring-pin configuration advantageously generates more ozone than prior art configurations, or the configurations of FIGS. 4A–4H. For example, whereas the configurations of FIGS. 4A–4H may generate perhaps 50 ppb ozone, the configuration of FIG. 4I can generate about 2,000 ppb ozone, without an increase in demand upon power supply B1.

Nonetheless it will be appreciated that applicants' first array pin electrodes may be utilized with the second array electrodes of FIGS. 4A–4H. Further, applicants' second array ring electrodes may be utilized with the first array electrodes of FIGS. 4A–4H. For example, in modifications of the embodiments of FIGS. 4A–4H, each wire or columnar electrode 232 is replaced by a column of electrically series-connected pin electrodes (e.g., as shown in FIGS. 4I–4K), while retaining the second electrode arrays as depicted in these figures. By the same token, in other modifications of the embodiments of FIGS. 4A–4H, the first array electrodes can remain as depicted, but each of the second array electrodes 242 is replaced by a column of electrically series-connected ring electrodes (e.g., as shown in FIGS. 4I–4K).

In FIG. 4J, a detailed cross-sectional view of the central portion of electrode 242 in FIG. 4I is shown. As best seen in FIG. 4J, curved region 246 adjacent the central opening in electrode 242 appears to provide an acceptably large surface area to which many ionization paths from the distal tip of electrode 232 have substantially equal path length. Thus, while the distal tip (or emitting tip) of electrode 232 is advantageously small to concentrate the electric field between the electrode arrays, the adjacent regions of electrode 242 preferably provide many equidistant inter-electrode array paths. A high exit flowrate of perhaps 90 feet/minute and 2,000 ppb range ozone emission attainable with this configuration confirm a high operating efficiency.

In FIG. 4K, one or more electrodes 232 is replaced by a conductive block 232" of carbon fibers, the block having a distal surface in which projecting fibers 233-1, . . . 233-N take on the appearance of a "bed of nails". The projecting fibers can each act as an emitting electrode and provide a plurality of emitting surfaces. Over a period of time, some or all of the electrodes will literally be consumed, whereupon graphite block 232" will be replaced. Materials other than graphite may be used for block 232" providing the material has a surface with projecting conductive fibers such as 233-N.

FIG. 5 depicts the location of a typical electrode assembly 220 within the head portion of brush 100, such that second electrode array 240 is closer to the brushing surface of the brush than is first electrode array 230. While FIG. 5 depicts an electrode assembly 220 using the ring-pin configuration of FIG. 4I, it is understood that any of the alternative configurations of FIGS. 4A–4G could instead be contained within brush 100. FIG. 5 also depicts the optionally removable nature of bristle block 145, and a different configuration of exit vents 150. FIG. 5 herein differs from FIG. 5 in the parent application only in the depiction of relatively shorter bristles herein.

Preferably the inner portion of the head region of brush 100 includes an electrostatic shield that reduces detectable electromagnetic radiation outside of the brush. For example, a metal shield could be disposed within the housing, or portions of the interior of the housing could be coated with a metallic paint to reduce such radiation.

It will also be appreciated that the net output of ions could be influenced by placing a bias element near some or all of the output vents. For example, such an element could be electrically biased to neutralize negative ions, thereby increasing the net output of positive ions. It will also be appreciated that the present invention could be adjusted to produce ions without producing ozone, if desired.

Modifications and variations may be made to the disclosed embodiments without departing from the subject and spirit of the invention as defined by the following claims.

What is claimed is:

1. A self-contained ion emitting brush, comprising:

a handholdable body defining at least one vent and having a region to which a grooming attachment may be removably affixed;

a self-contained ion generator disposed in said body and including:

a high voltage generator having first and second output ports, one of which ports may be at a same potential as ambient air, that outputs a signal whose duty cycle can be about 10% to about 100%; and

an electrode assembly, effectively coupled between said output ports, comprising a first electrode array that includes at least one electrically conductive electrode having a pointed tip aimed generally in a downstream direction, and a second electrode array that includes at least one electrically conductive member through which there is defined at least one substantially circular opening disposed generally coaxial with and in a downstream direction from said pointed tip of said electrically conductive electrode, said electrically conductive member having a surface that faces said first electrode array and transitions smoothly and continuously to surround a periphery of said substantially circular opening;

wherein said ion generator outputs an electrostatic flow in a downstream direction toward said second electrode array, said electrostatic flow including at least one of ionized air and ozone.

2. The brush of claim 1, wherein:

said second electrode array is a loop of electrically conductive material.

3. The brush of claim 1, wherein:

said first electrode array includes at least two electrodes that each have a pointed tip aimed generally toward said opening; and

said second electrode array is a single ring of electrically conductive material encircling said substantially circular opening.

4. The brush of claim 1, wherein:

said first electrode array includes at least a first electrically conductive electrode having a pointed tip aimed generally in said downstream direction, and a second electrically conductive electrode having a pointed tip aimed generally in said downstream direction; and

said second electrode array includes at least a first electrically conductive member through which there is defined a substantially circular opening disposed generally coaxial with and in a downstream direction from said pointed tip of said first electrically conductive electrode, and a second electrically conductive member through which there is defined a substantially circular opening disposed generally coaxial with and in a downstream direction from said pointed tip of said second electrically conductive electrode.

5. The brush of claim 1, wherein:

said first electrode array includes at least one electrode made from a material having a distal end that defines a plurality of projecting conductive fibers.

6. The brush of claim 1, wherein a region of said electrically conductive member surrounding said opening has an effective radius of curvature exceeding an effective radius of curvature of said pointed tip of said electrically conductive electrode by a ratio of at least 10:1.

7. The brush of claim 1, wherein said high voltage generator provides a first potential measurable relative to ground to said first electrode array and provides a second potential measurable relative to ground to said second electrode array.

8. The brush of claim 7, wherein at least one of said first potential and said second potential has an absolute magnitude of at least about 1 kV.

9. The brush of claim 1, further including said grooming attachment.

10. The brush of claim 1, wherein said electrically conductive member in said second electrode array has at least one characteristic selected from a group consisting of (i) said member defines in cross-section a smoothly and continuously tapered region terminating towards said generally circular opening, (ii) said member defines in cross-section a rounded region terminating smoothly and continuously towards said generally circular opening, (c) said member defines in cross-section a smooth and continuous rounded profile terminating in said generally circular opening, (d) a ratio of effective radius of a rounded surface region of said member surrounding said periphery of said generally circular opening to effective radius of said pointed tip of said electrically conductive electrode exceeds about 15:1, and (e) said member includes stainless steel.

11. The brush of claim 1, wherein said electrically conductive electrode in said first electrode array has at least one characteristic selected from a group consisting of (a) said electrode includes tungsten, (b) said electrode includes stainless steel, and (c) said electrode includes projecting fibers of carbon.

12. A method of providing a self-contained ion emitting brush, comprising the following steps:

(a) providing a handholdable body defining at least one vent and including a region to which region a grooming attachment may be detachably affixed;

(b) disposing within said body an electrode assembly comprising a first electrode array that includes at least one electrically conductive electrode having a pointed tip aimed generally in a downstream direction, and a second electrode array that includes at least one electrically conductive member through which there is defined at least one substantially circular opening disposed generally coaxial with and in a downstream direction from said pointed tip of said first electrode, said electrically conductive member having a surface that faces said first electrode array and transitions smoothly and continuously to surround a periphery of said substantially circular opening; and

(c) within said body, generating high voltage with a duty cycle that can be about 10% to about 100% and coupling said high voltage across said first electrode array and said second electrode array;

wherein an electrostatic flow in a downstream direction toward said second electrode array is created, said electrostatic flow including at least one of ionized air and ozone.

13. The method of claim 12, wherein step (b) includes providing said second electrode array as a loop of electrically conductive material.

14. The method of claim 12, wherein step (b) includes providing said first electrode array with at least two electrodes that each have a pointed tip aimed generally toward said opening; and providing said second electrode array as a single ring of conductive material encircling said generally circular opening.

15. The method of claim 12, wherein step (b) includes:

providing said first electrode array that includes at least a first electrically conductive electrode having a pointed tip aimed generally in said downstream direction, and a second electrically conductive electrode having a pointed tip aimed generally in said downstream direction; and

providing said second electrode array with at least a first electrically conductive member through which there is defined a substantially circular opening disposed gen-

erally coaxial with and in a downstream direction from said pointed tip of said first electrically conductive electrode, and a second electrically conductive member through which there is defined a substantially circular opening disposed generally coaxial with and in a downstream direction from said pointed tip of said second electrically conductive electrode.

16. The method of claim 12, wherein step (b) includes:

providing said first electrode array with at least one electrically conductive electrode made from a material having a distal end that includes a plurality of projecting conductive fibers.

17. The method of claim 12, wherein step (b) includes rounding a surface region of said electrically conductive member facing said first electrode array and surrounding said generally circular opening such that a ratio of effective radius of the rounded said surface region of said electrically conductive member to effective radius of said pointed tip of said first electrically conductive electrode exceeds about 10:1.

18. The method of claim 12, wherein step (c) includes generating and coupling said high voltage to provide a first potential measurable relative to ground to said first electrode array and to provide a second potential measurable relative to ground to said second electrode array.

19. The method of claim 12, wherein at least one of said first potential and said second potential has an absolute magnitude of at least about 1 kV.

20. A self-contained ion emitting brush, comprising:

a handholdable body defining at least one vent and having a region to which a grooming attachment may be affixed;

a self-contained ion generator disposed in said body and including:

a high voltage generator having first and second output ports, one of which ports may be at a same potential as ambient air, that outputs a signal whose duty cycle can be about 10% to about 100%; and

an electrode assembly, effectively coupled between said output ports, comprising a first electrode array that includes at least one wire electrode, and a second electrode array that includes at least two electrically conductive members that are disposed parallel to said wire electrode and are equidistant therefrom, and that in cross-section define at least half of a U-shape;

wherein said ion generator outputs an electrostatic flow in a downstream direction toward said second electrode array, said electrostatic flow including at least one of ionized air and ozone.

21. The brush of claim 20, wherein said electrically conductive members in said second electrode array include at least two electrically conductive electrodes that in cross-section each define a U-shape having a bulbous nose region facing toward said first electrode array, and have first and second trailing edge regions.

22. The brush of claim 21, wherein an electrode in said second electrode array has at least one characteristic selected from a group consisting of (a) a portion of one of said trailing edge regions is longer than a remaining trailing edge region on said electrode, (b) a portion of one of said trailing edge regions defines at least one pointed projection facing downstream, and (c) a ratio of effective radius of an electrode in said second electrode array to effective radius of said wire electrode in said first electrode array exceeds about 15:1.

23. The brush of claim 20, wherein:

said second electrode array includes at least two electrically conductive electrodes that in cross-section define an L-shape having a curved nose region facing said first electrode array.

24. The brush of claim 20, wherein a portion of electrodes in said second array include at least one pointed projection facing downstream.

25. The brush of claim 20, wherein:

said second electrode array includes at least two electrically conductive electrodes that in cross-section define a hollow shape.

26. The brush of claim 25, wherein a ratio of effective radius of one of said hollow-shape electrodes to radius of said wire electrode exceeds about 15:1.

27. A method of providing a self-contained ion emitting brush, comprising the following steps:

(a) providing a handholdable body defining at least one vent and including a region to which a grooming attachment may be detachably affixed;

(b) disposing within said body an electrode assembly comprising a first electrode array including a wire electrode, and a second electrode array including at least two electrically conductive members disposed parallel to said wire electrode and equidistant therefrom, each of said conductive members that in cross-section define a hollow shape; and

(c) within said body, generating high voltage with a duty cycle that can be about 10% to about 100% and coupling said high voltage across said first electrode array and said second electrode array;

wherein an electrostatic flow is created that flows downstream toward said second electrode array, said electrostatic flow including at least one of ionized air and ozone.

28. The method of claim 27, wherein step (b) includes providing said electrically conductive members in said second electrode array with at least two electrically conductive electrodes that in cross-section define a U-shape having a bulbous nose region facing said wire electrode, and first and second trailing edge regions.

29. The method of claim 27, wherein step (b) includes providing said second electrode array with at least two electrically conductive electrodes that in cross-section define an L-shape having a curved nose region facing said wire electrode.

30. The method of claim 27, wherein step (b) includes providing said second electrode array with electrodes having an effective radius such that a ratio between said effective radius and a radius of said wire electrode exceeds about 10:1.

31. The method of claim 27, wherein step (b) includes providing at least one of said electrically conductive members in said second electrode array with an edge portion that includes at least one pointed projection facing downstream.

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